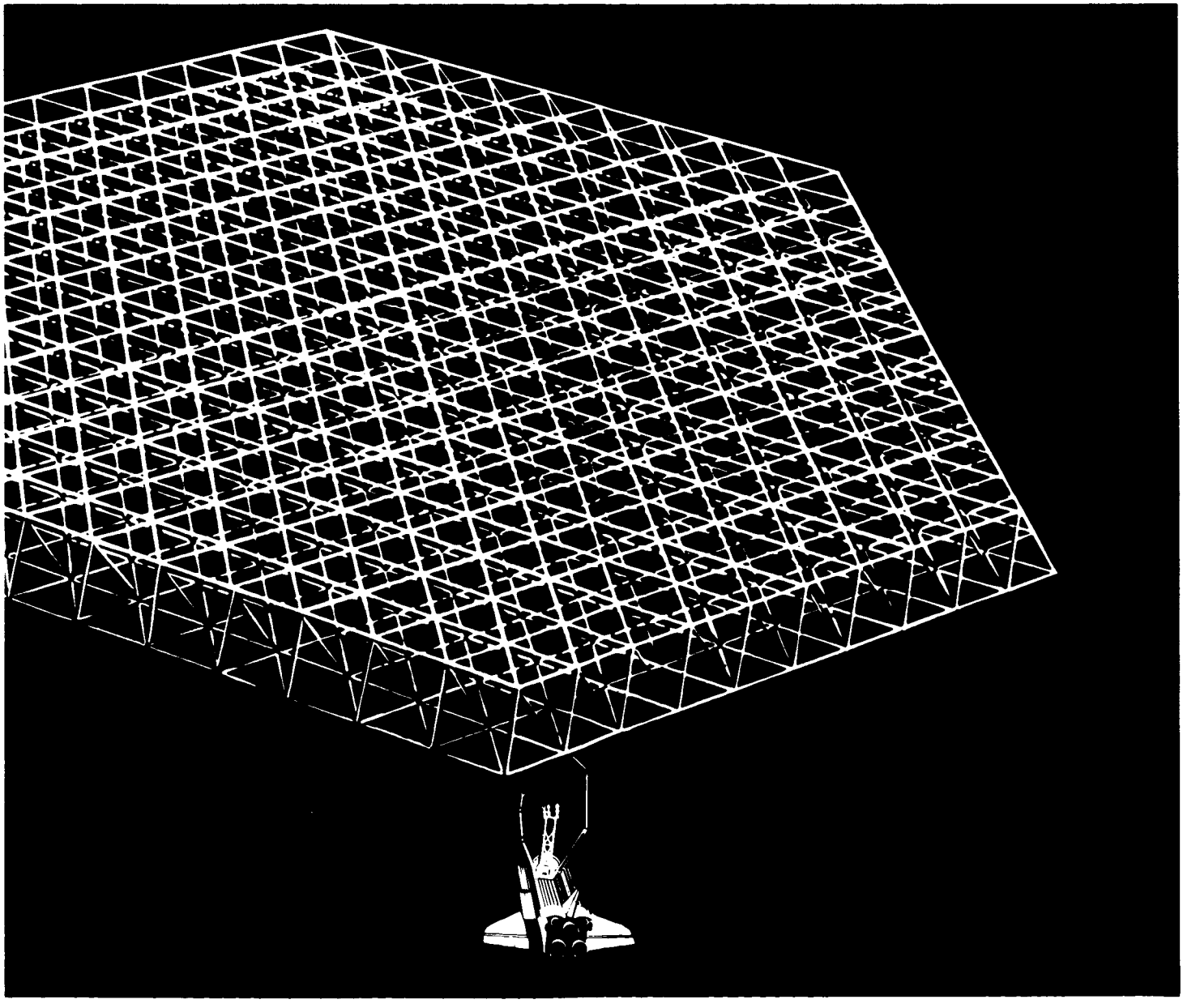
NASA

Technology for Large Space Systems

NASA SP-7046(16)

May 1987

A Bibliography
with Indexes



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TECHNOLOGY FOR LARGE SPACE SYSTEMS

A BIBLIOGRAPHY WITH INDEXES

Supplement 16

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A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system between July 1 and December 31, 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA
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NOTE TO AUTHORS OF PROSPECTIVE ENTRIES:

The compilation of this bibliography results from a complete search of the *STAR* and *IAA* files. Many times a report or article is not identified because either the title, abstract, or key words did not contain appropriate words for the search. A number of words are used, but to best insure that your work is included in the bibliography, use the words *Large Space Structures* somewhere in your title or abstract, or include them as a key word.

This supplement is available from the National Technical Information Service (NTIS), Springfield , Virginia 22161 at the price code A09.

INTRODUCTION

This bibliography is designed to be helpful to the researcher and manager engaged in the developing technology within the discipline areas of the Large Space Systems Technology (LSST). Also, the designers of large space systems for approved missions (in the future) will utilize the technology described in the documents referenced herein.

This literature survey lists 673 reports, articles and other documents announced between July 1, 1986 and December 31, 1986 in *Scientific and Technical Aerospace Reports (STAR)*, and *International Aerospace Abstracts (IAA).*

The coverage includes documents that define specific missions that will require large space structures to achieve their objectives. The methods of integrating advanced technology into system configurations and ascertaining the resulting capabilities is also addressed.

A wide range of structural concepts are identified. These include erectable structures which are earth fabricated and space assembled, deployable antennas which are fabricated, assembled, and packaged on Earth with automatic deployment in space, and space fabricated structures which use pre-processed materials to build the structure in orbit.

The supportive technology that is necessary for full utilization of these concepts is also included. These technologies are identified as analysis and design techniques, structural and thermal analysis, structural dynamics and control, electronics, advanced materials, assembly concepts, and propulsion.

A separate companion document "Space Station Systems Bibliography" (NASA SP-7056) incorporates space station technology not applicable to large space systems. Space station systems technology that is also applicable to large space systems may be documented in both bibliographies.

Robert L. Wright, *Space Systems Division*
Sue K. Seward, *Technical Library Branch*

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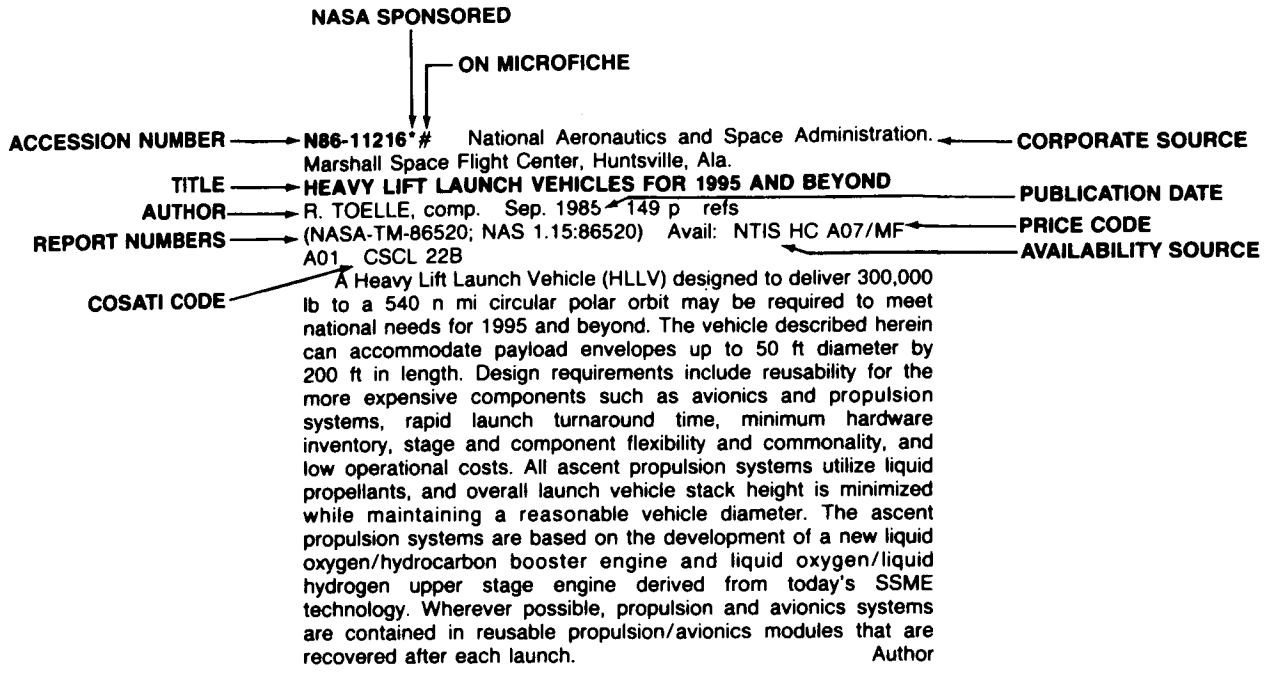
TYPICAL REPORT CITATION AND ABSTRACT



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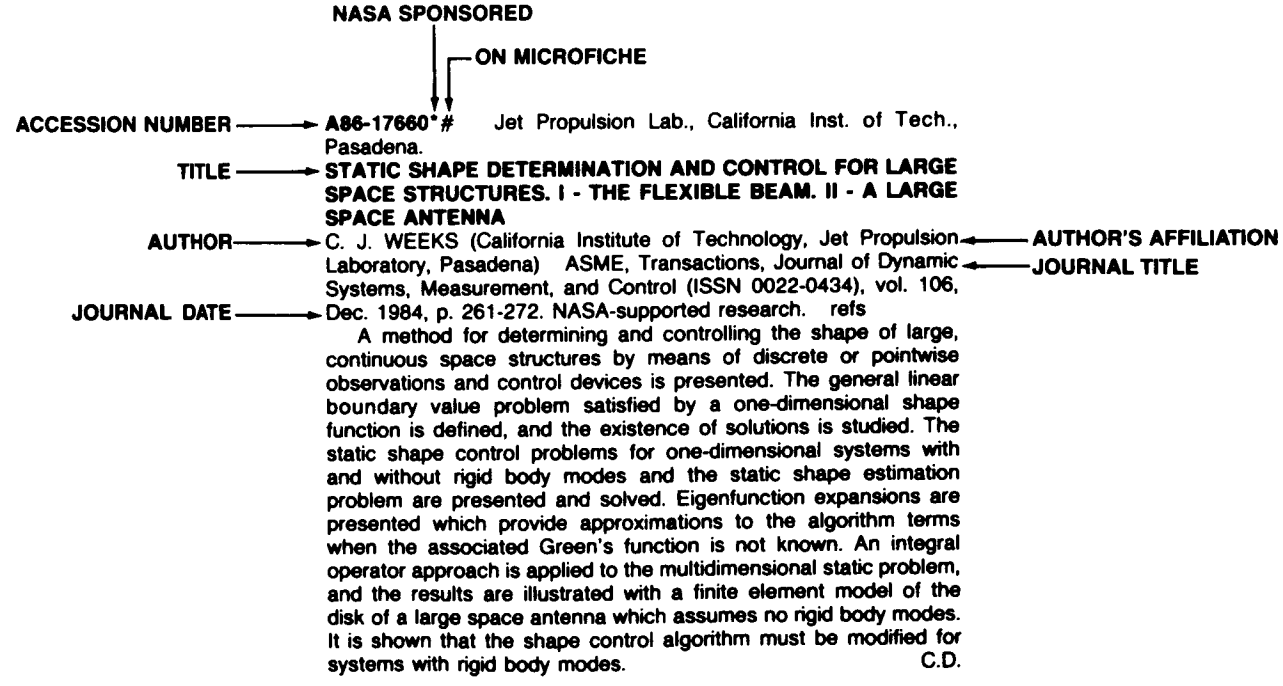

TECHNOLOGY FOR LARGE SPACE SYSTEMS

A Bibliography (Suppl. 16)

MAY 1987

01

SYSTEMS

Includes mission and program concepts and requirements, focus missions, conceptual studies, technology planning, systems analysis and integration, and flight experiments.

A86-30117* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
STRATEGIES FOR A PERMANENT LUNAR BASE
M. B. DUKE, W. W. MENDELL, and B. B. ROBERTS (NASA, Johnson Space Center, Houston, TX) IN: Lunar bases and space activities of the 21st century . Houston, TX, Lunar and Planetary Institute, 1985, p. 57-68. refs

One or more of three possible objectives, encompassing scientific research, lunar resource exploitation for space infrastructure construction, and lunar environment self-sufficiency refinement with a view to future planetary habitation, may be the purpose of manned lunar base activities. Attention is presently given to the possibility that the early phases of all three lunar base orientations may be developed in such a way as to share the greatest number of common elements. An evaluation is made of the cost and complexity of the lunar base, and the Space Transportation System used in conjunction with it, as functions of long term base use strategy. O.C.

A86-30180
LUNAR INDUSTRALIZATION AND SETTLEMENT - BIRTH OF POLYGLOBAL CIVILIZATION
K. A. EHRICKE (Space Global, La Jolla, CA) IN: Lunar bases and space activities of the 21st century . Houston, TX, Lunar and Planetary Institute, 1985, p. 827-855. refs

Major aspects of lunar industrialization and settlement are presented, together with evolutionary justification for this settlement. Three interlocking phases of open-world development are defined: (1) exoindustrialization, the capability of productive existence in the new environment; (2) space urbanization, the capability of establishing large-scale industrial and biotechnically productive settlements; and (3) extraterrestrialization, the prolonged process of socio-psychological development and anthropological divergence based on the integration and further evolution of the first two phases. Lunar development, which offers the earliest, highest benefit relevance to terrestrial humanity and to the development of cislunar space, involves five developmental stages (DS): DS-1, the synoptic prospecting for mineralogical provinces and a candidate base site; DS-2, the establishment of a circumlunar space station; DS-3, the establishment of a nuclear powered central lunar processing complex, initiating industrial production; DS-4, productivity diversification through feeder stations in distant metallogenic provinces; and DS-5, the founding of Selenopolis, a self-sustaining lunar civilization. Technoogical approaches, ecnonomic strategies, mining techniques, energy and transportation are discussed along with socioanthropological factors. A systematic approach to creating a positive earth-moon balance of trade is proposed. K.K.

A86-32413* Arizona Univ., Tucson.
AN OVERVIEW OF OPTICAL TELESCOPE TECHNOLOGY
A. B. MEINEL (Arizona, University, Tucson) and M. P. MEINEL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Optical Fabrication and Testing Workshop: Large Telescope Optics, Albuquerque, NM, March 4-8, 1985, Proceedings . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 35-41.

Telescopes had tended to follow established designs until costs made it essential to look toward significant departures from conventional designs. Attempts to introduce some new concepts were without success until the Multiple Mirror Telescope broke the established pattern. Now several new possibilities are being engineered for the very large telescopes of the future. Author

A86-32536
STRATEGIES TO MINIMIZE DELTA V COSTS OF EXTRATERRESTRIAL RESOURCES
C. P. MEINEL (Analytic Decisions, Inc., Arlington, VA) and K. PARKS (Arizona, University, Tucson) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 111-127. refs

According to the projected U.S. space activities in the 1990s, large amounts of structural elements may be needed which might be readily produced in orbit if suitable raw materials were available. This paper is concerned with the possible sources of raw materials for space activities, and the delivery of these resources to users with minimum fuel cost. Attention is also given to missions to known near-earth asteroids with high mass payback ratios on fuel consumption, and the conditions suitable for a participation of private capital in a mining mission. The resources of moons and asteroids are considered along with the minimization of velocity difference (Delta V) costs among earth, lunar, and asteroidal resources. Other topics explored are related to an electromagnetic launch, the round trip problem, asteroid mission opportunities, the search for near-earth asteroids, the advantages of the high elliptical earth orbit, and means to minimize fuel use. G.R.

A86-32540*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ACCESS (ASSEMBLY CONCEPT FOR CONSTRUCTION OF ERECTABLE SPACE STRUCTURE) - A SHUTTLE FLIGHT EXPERIMENT
W. L. HEARD, JR. (NASA, Langley Research Center, Hampton, VA) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 157-165. refs

ACCESS is a planned Shuttle flight experiment to assess the potential of an on-orbit construction concept designed for efficient manual assembly of a space truss. The experiment, which is scheduled for launch November 27, 1985, on the Space Transportation System (STS) flight 61-B, uses two astronauts secured in fixed foot restraints located in the Shuttle cargo bay to assemble a 45-foot long aluminum truss beam from 93 tubular struts and 33 nodal joints. Neutral buoyancy simulations of the flight experiment indicate the truss can be assembled in less than

thirty minutes. Structural assembly, structural repair, flexible cable attachment and manual manipulation of the truss is also planned for the experiment using an astronaut secured in the Manipulator Foot Restraint attached to the Remote Manipulator System arm. Flight assembly data will be generated for correlation of the neutral buoyancy ground test data. This paper describes the ACCESS flight experiment and presents results of the neutral buoyancy development and training tests. Author

A86-32543*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION ADVANCED DEVELOPMENT PROGRAM
R. F. CARLISLE (NASA, Office of Space Station, Washington, DC) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 183-191.

The Space Station Advanced Development Program has the objective to transform promising new techniques into mature proven concepts to enable design options for the initial Space Station. It is pointed out that the options should improve system performance and reduce operational costs. Attention is given to the approach employed in the implementation of the program, the technology issues, aspects of Space Station evolution and growth, a Space Station technology overview, and subsystem technologies. The Advanced Development Power Program is considered along with the advanced development of auxiliary propulsion, the program dealing with attitude control and stabilization, and developments related to data management. Other developments are concerned with communication, system operation, manned systems technology, structures, and environmental control and life support. G.R.

A86-32547
GEOSTATIONARY COMMUNICATIONS PLATFORMS
J. V. BROWN and N. J. BARBERIS (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 207-209.

In early 1984, NASA released two requests for proposal (RFPs) designed to answer several questions concerning geosynchronous (GEO) communications platforms. One RFP, released by NASA's Lewis Research Center, was designed to establish 'what aggregation of communications payloads, if any, would be appropriate for a commercial GEO communications platform in the mid- to late 1990s'. A second RFP, released by NASA's Marshall Space Flight Center, was designed to 'address the requirements for future spacecraft buses, space transportation systems and space operations capabilities necessary to enable GEO communications platforms'. The aggregated communications payloads developed in the NASA/Lewis study are briefly discussed, while primary attention is given to the results obtained to date in the NASA/Marshall platform bus studies. G.R.

A86-32548*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
MARS MISSIONS AND BASES - A RECENT LOOK
J. M. BUTLER, JR. (NASA, Marshall Space Flight Center, Huntsville, AL) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 211-222. refs

This paper discusses some of the key options for Mars programs, missions, bases, elements, and systems. Program and mission options include Mars flyby, orbiting, and landing missions; they include near-term 'sortie' missions, and later, longer-duration Mars-base missions. Key program and mission parameters include the mix of manned/unmanned elements, the number and types of space vehicles used, types of science done, trajectory options and implications launch timing and schedules, etc. The key mission parameters strongly affect the nature, sizing, and quantity of earth-to-orbit (ETO) vehicles. On-orbit assembly of space vehicles (SVs) is also an important related consideration. The potential degree of utilization of the Space Station (SS) and other then-existing elements is a key question, and several possibilities are discussed in this paper. Several configurations of SVs are provided. Several options are identified for the Mars base infra-structure, and parametric data is shown for buildup of bases as a function of mission and vehicle type. Technologies required for the missions are also discussed. Author

A86-32566*# National Aeronautics and Space Administration, Washington, D.C.
THE NASA FLIGHT DEMONSTRATION PROGRAM
G. M. LEVIN (NASA, Washington, DC) and D. ROUTH (NASA, Marshall Space Flight Center, Huntsville, AL) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 371-378.

The Flight Demonstration Program was initiated by the Office of Space Flight in October 1983. The purposes of this program are to conduct an ongoing series of flight demonstrations which demonstrate critical enabling technology to potential Shuttle users and at the same time provide hands on experience to NASA engineers. Flight demonstrations are selected through a peer review process in response to an annual solicitation issued by the Flight Demonstration Office at NASA Headquarters. As of July 1985 one major flight demonstration has been successfully conducted, two flight demonstrations are scheduled to fly in November on STS 61-B, and five flight demonstrations are in various stages of development and planned to be flown during the next three years. Author

A86-34594* National Aeronautics and Space Administration, Washington, D.C.
NASA SPACE PLANS AND SCENARIOS TO 2000 AND BEYOND
Park Ridge, NJ, Noyes Publications, 1986, 252 p.

NASA's research and development plans, as reflected in its missions, goals, and objectives to the year 2000 and beyond, are presented. New starts for the next decade and space program activities are highlighted, including space science and applications, space flight, space stations, space tracking and data systems, and space research and technology. Space programs for the 21st century are also covered. C.D.

A86-34962* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
INITIATION OF THE NEXT STEP - THE ACQUISITION OF A SPACE STATION PROGRAM
T. G. MANCUSO (NASA, Johnson Space Center, Houston, TX) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 3-1 to 3-4.

Attention is given to NASA's Space Station Program acquisition strategy, as well as the internal implementation of the strategy and the nature of NASA's relations with industry. While the acquisition strategy addresses phased procurement, design-to-cost, and advanced development emphasis, internal implementation concerns itself with 'skunk works' activities and the exploitation of the Technical and Management Information System. NASA's relationship to contractors will stress competition, extensive commercial and international involvement, and design/development phase competition flexibility. O.C.

A86-35173#
EUROPEAN SPACE PLATFORM DEVELOPMENTS
G. ALTMANN and W. NELLESSEN (ESA, Paris, France) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 28 p. (DGLR PAPER 85-123)

The present paper is concerned with European activities related to the development of automated space platforms for low earth orbits. In the context of this paper, the term 'space platform' is used to describe 'reusable carrier systems providing basic resources and standard interfaces to temporarily attached payloads which can be replaced on orbit or on the ground'. The status of European platform developments is considered, taking into account potential platform developments based on the Spacelab pallet, the platform concept of Robus, the Spas (Shuttle-Pallet-Satellite) platform concept, the Eureca (European Retrievable Carrier) platform concept, and concepts for future space-based platforms. European developments are evaluated, taking into account efforts to establish cost effective design and operational concepts which are commercially attractive. G.R.

A86-35217 National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WEIGHTS ASSESSMENT FOR ORBIT-ON-DEMAND VEHICLES
I. O. MACCONOCHIE, J. A. MARTIN (NASA, Langley Research Center, Hampton, VA), C. A. BREINER, and J. A. CERRO (Kentron International, Inc., Hampton, VA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 32 p. refs
(SAWE PAPER 1674)

Future manned, reusable earth-to-orbit vehicles may be required to reach orbit within hours or even minutes of a mission decision. A study has been conducted to consider vehicles with such a capability. In the initial phase of the study, 11 vehicles were sized for deployment of 5000 lbs to a polar orbit. From this matrix, two of the most promising concepts were resized for a modified mission and payload. A key feature of the study was the use of consistent mass estimating techniques for a broad range of concepts, allowing direct comparisons of sizes and weights. Author

A86-35319
MORE SPACE IN SPACE
I. PARKER Space (ISSN 0267-954X), vol. 2, Mar.-May 1986, p. 14, 15.

In response to demands made by the scientific community and the DOD, Spacehab has signed a memorandum of understanding with NASA for the development of modules which would increase SS living and working space by 1000 cubic feet by the year 1988. These modules, comprised of truncated aluminum alloy cylinders, will carry up to 2700 kg of payload. The basic version of the module will share environmental control/life support resources with the mid-deck and will have passive thermal control. With project costs estimated at 50 million U.S. dollars, Spacehab will provide full service to NASA including mission support and post-flight services. K.K.

A86-35518
AIR AND SPACE TRAVEL - TASKS FOR THE FUTURE [LUFT- UND RAUMFAHRT - AUFGABEN DER ZUKUNFT]
F. J. STRAUSS (DFVLR, Jahreshauptversammlung, Munich, West Germany, Nov. 11, 1985) DFVLR-Nachrichten (ISSN 0011-4901), March 1986, p. 3-5. In German.

The past and present states of the European space effort are reviewed, and recommendations for the future course of action are presented. The importance of a united, vigorous European space program in competition with the United States space program is emphasized. The benefits flowing from European participation in the Strategic Defense Initiative are discussed. The European Eureka project is criticized for costing too much money while producing few results. C.D.

A86-36035#
THE GIOTTO SPACECRAFT'S PERFORMANCE DURING THE GEOSTATIONARY TRANSFER ORBIT AND NEAR-EARTH MISSION PHASES
J. L. TRACY, F. FELICI, D. LEVINS, and F. C. VANDENBUSSCHE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 9, no. 3, 1985, p. 375-391.

Design features and the results of operational status checks of Giotto in the early flight stages are summarized. Successful spin-up to 15 rpm was performed once a 200 km orbit was attained. The spin was soon increased to 90 rpm before firing the Mage booster to put Giotto in a heliocentric orbit. Calibration of the thrusters was performed between the steps of the spin-up. Booster firing was accurate to within 3 m/sec of the intended velocity, thereby precluding any necessity for corrective firings. Thrusters were then fired to despin the outward bound spacecraft for earth pointing. Nutation was determined to be within the expected range, although numerous slew adjustments were required to achieve satisfactory earth pointing. The on-board power system, fueled by solar panels, ran flawlessly and never permitted depth-of-discharge data to be acquired for the batteries, which shared power well. The tests validated the performance of the mechanical and thermal subsystems, although a retraction of the bumper shield was required to offset a temperature rise that exceeded expectations during firing of the kick motor. M.S.K.

A86-37853*# National Aeronautics and Space Administration, Washington, D.C.
THE U.S. SPACE STATION PROGRAM
P. E. CULBERTSON (NASA, Office of Space Station, Washington, DC) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 11-22.

An overview is given of the U.S. Space Station program, beginning with President Reagan's directive to NASA 'to develop a permanently manned Space Station and to do it within a decade'. The international aspects of the project are emphasized, and fruitful cooperation between Italy and the U.S. in past and present space research is noted. The Station is to serve diverse functions, including that of a laboratory in space, a permanent observatory, a servicing facility, a transportation node, and assembly and manufacturing facility, a storage depot, and a staging base for future endeavors. Management-related and engineering-related guidelines are laid out. The plan is to make the Space Station a legacy from this century to the next, with the help of and to the benefit of all who share our goals. D.H.

A86-37854#
COLUMBUS - THE EUROPEAN PARTICIPATION IN INTERNATIONAL SPACE STATIONS
E. VALLERANI (Aeritalia S.p.A., Gruppo Sistemi Spaziali, Turin, Italy) and H. E. W. HOFFMANN (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 29-44.

A history of the Columbus project to date is presented, beginning with the demonstration by ESA and its member States that there is a capability to take on a project of this magnitude. Columbus is intended to complement the U.S. Space Station, being (in one concept) a free-flying facility in orbit near the Space Station. It will be manned and serviced as needed from time to time by personnel who actually reside on the Space Station. The Columbus system is to consist of four elements: the pressurized module; the resource module; the payload platform; and the servicing vehicle. Anticipated to be ready by 1992 (the 500th anniversary of Columbus' discovery of America), the system will have the potential of evolving to meet future needs. D.H.

A86-37856#
THE COLUMBUS PREPARATORY PROGRAMME SUPPORTING TECHNOLOGY OF THE EUROPEAN SPACE AGENCY
H. STOEWER and R. BARBERA (ESA, Systems Engineering Dept., Noordwijk, Netherlands) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 79-96.

The status of preparation for the technical and program aspects of the European Space Agency's Columbus Preparatory Technology Research and Development activities is summarized. Technology R&D activities for the manned module, unmanned platforms including resources technologies and servicing vehicles are described. Priorities, funding allocations, and schedule aspects for industrial implementation are indicated. The Supporting Technology together with the Phase B System Definition studies permit ESA and European industry to work together toward the 1986/87 milestone for Columbus Phase C/D implementation. The process of going from the system definition phase to supporting-technology development should provide a valuable data base and give confidence in the technical, cost and schedule predictions already derived. D.H.

A86-37862#
A PAYLOAD FOR UTILIZATION OF SPACE PLATFORM IN THE FIELD OF COMMUNICATION AND EARTH OBSERVATION
F. SCIARRINO (Contraves Italiana S.p.A., Rome, Italy) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 185-197.

Experiments in the field of communication and earth observation are described which can be carried out on board the Space Platform and the Shuttle Tethered Satellite. Three payloads are discussed. SLACOM will be a space platform adaptive communication module to perform a series of experiments to investigate new K-band, C-band, and L-band techniques for improving point-to-point communications via satellite. A microwave SAR (synthetic aperture radar) will be used for high resolution imaging of land surfaces and ocean waves, monitoring earth resources, disaster assessment, navigation aids, weather and sea-state forecasting, altimetry, and subsatellite tracking. COMLINK will be an experiment using a conducting tether 10-100 km long connecting a transmitter on a subsatellite to a Space Shuttle orbiting at a higher altitude; both communications and tethering technology can be tested. D.H.

A86-37863#
INFLATABLE TECHNOLOGY IN ORBIT DEMONSTRATION WITHIN THE EUROPEAN SPACE AGENCY PROGRAMS
G. G. REIBALDI (ESA, Mechanical Systems Div., Noordwijk, Netherlands) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 199-205.

To support future space projects in general and the Space Station program in particular, the European Space Agency has proposed to the European countries an in-orbit technology demonstration experiment, designated 'Inflatable Space Rigidized Technology' or ISRT. ISRT has been developed within the ESA Technology Research Program, and the technology has been applied to design large size reflecting telescopes. A first in-orbit demonstration on the Space Shuttle of a 3.5-m scale model was planned for early 1986. A full-scale 14-m off-set reflector in-orbit demonstration is proposed for the middle of 1988. D.H.

A86-37868*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION UTILIZATION
W. P. RANEY (NASA, Office of Space Station, Washington, DC) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 251-256.

The essential requirement of the Space Station that the customer be continually involved in all aspects of the program is considered. Potential users of the Space Station need both formal and informal channels into the program at an early stage of the definition process to secure their influence and participation in the development process. Only with this participation can users' needs and requirements be integrated into the design phase to produce 'user friendliness' in the Space Station. A Space Station that is easy and economical to use will generate more users that can take advantage of the available resources. The Space Station must be: a research facility; a satellite servicing and assembly facility; an observatory for terrestrial, solar, and astronomical viewing; and a transportation node for orbit transfer vehicles. NASA intends to see that the Space Station is developed and operated so as to serve its users. D.H.

A86-37869#
UNITED STATES SCIENTIFIC COMMUNITY VIEWS OF THE SPACE STATION
B. LICHTENBERG (Payload Systems, Inc., Wellesley, MA) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 257-264.

Results are presented from a summer (1983) study conducted by the Task Force on the Scientific Uses of the Space Station. The charter of the committee is: (1) to assist NASA in planning for the scientific utility of the space station; (2) to assist NASA in understanding the relationship between the existing and new parts of the space program; (3) to periodically update scientific requirements on Space Station hardware and operations; and (4) to act as a focal point for the U.S. science community and to interact as needed with contractors during the definition phase of the program. Science discipline teams included: astronomy and astrophysics; solar system exploration and planetary science; solar-terrestrial processes; earth observations; life sciences; microgravity sciences and applications; and physics and chemistry in space. Major concerns are flexibility, adequate resources, and easy access. Strong emphasis was put on a continuing Shuttle experiment program, including a request for additional power resources to enable the Shuttle to remain in orbit for up to 15 days. D.H.

A86-37872#
MISSION REQUIREMENTS FOR COORBITING AND POLAR PLATFORMS - A CRITICAL SURVEY
G. MANNARA, L. G. NAPOLITANO, and R. MONTI (Napoli, Universita, Naples, Italy) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 325-337. In Italian. refs

Missions proposed for platforms in the Space Station program are analyzed. Mission requirements are characterized for polar platforms and those coorbiting with the Space Station. It is concluded that polar platforms should satisfy different requirements from coorbiting platforms; the former should emphasize servicing operations while the latter should emphasize flexibility. B.J.

A86-38100
PIONEERING THE SPACE FRONTIER
New York, Bantam Books, 1986, 221 p. No individual items are abstracted in this volume.

The goals and plans of the program for exploration and development of the space frontier recommended by the National Commission on Space for the next 50 years are described. The topics discussed include civilian space goals for 21st-century America, low-cost access to the solar system, opening the space frontier, and American leadership on the space frontier. Papers are presented on advancing science; exploring, prospecting, and settling the solar system; space enterprise and building the technology base; and on an economical, phased approach. In addition, consideration is given to the aspects of conducting an effective science program, government policy and the private sector, international cooperation and competition, 21st-century America, and to what the recommended program will do. I.S.

A86-38168
A COMPARATIVE ANALYSIS OF SPACE COLONIZATION ENTERPRISES
F. D. DRAKE (California, University, Santa Cruz) IN: The search for extraterrestrial life: Recent developments; Proceedings of the Symposium, Boston, MA, June 18-21, 1984 . Dordrecht, D. Reidel Publishing Co., 1985, p. 443-447.

It is shown that the energy requirements for interstellar colonization exceed that for intraplanetary colonization by a factor of ten million or perhaps much more. This is offered as an argument against extensive interstellar colonization as a means of dealing with population expansion, and as a possible explanation of the Fermi paradox. Author

A86-38273#
THE GIOTTO ASSEMBLY, INTEGRATION AND VERIFICATION PROGRAMME
H. BACHMANN and J. CREDLAND (ESA, Giotto Project Div., Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 45, Feb. 1986, p. 61-67.

The Assembly, Integration and Verification (AIV) program for ESA's Giotto satellite was designed to provide maximum possible confidence in the spacecraft system's ability to withstand the launch phase and to satisfy all of the mission objectives within the imposed program and cost constraints. Owing to Giotto's unique launch window in July 1985, and an encounter opportunity only every 76 years, the AIV program had to be constructed so as to endure such project problems as late delivery and malfunctioning units. In effect, alternative work flows and schedules had to be predefined so as to allow for increased flexibility and the incorporation of contingency plans. The overall AIV program is presented in detail, with emphasis placed on integration and electrical-system testing, and the environmental test program. In addition, a comparison is made between the original system plans and what was actually achieved. It is noted that all testing was successful and that the Giotto spacecraft was allowed to begin its mission as scheduled. K.K.

A86-39502*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL OF FLEXIBLE STRUCTURES (COFS) FLIGHT EXPERIMENT PROGRAM
A. FONTANA and B. R. HANKS (NASA, Langley Research Center, Hampton, VA) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 413-422.

The Control of Flexible Structures (COFS) Flight Experiment Program consists of a series of four Shuttle-attached experiments specifically designed to systematically evaluate algorithms and techniques for on-orbit systems identification and flexible body control of large flexible structures, and as such, develops the enabling technologies for future NASA missions such as the evolutionary Space Station and large orbital antennas. These flight experiments are conducted on 1-year centers starting in 1989. This paper presents a description of the test article for the first two flights (COFS-I) and a discussion of the strategy for conducting the various experiments. A guest investigator program provides the opportunity for the research community to participate in the structures/controls research associated with the multi-flight COFS Program. Author

A86-39905*# Grumman Aerospace Corp., Bethpage, N.Y.
THE SHARE FLIGHT EXPERIMENT - AN ADVANCED HEAT PIPE RADIATOR FOR SPACE STATION
J. P. ALARIO and P. J. OTTERSTEDT (Grumman Aerospace Corp., Space Systems Div., Bethpage, NY) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 10 p. NASA-sponsored research. refs
(AIAA PAPER 86-1297)

This paper reports on the design and thermal vacuum certification testing of the Space Station Heat Pipe Advanced Radiator Element (SHARE) Shuttle flight experiment, with primary emphasis on the heat pipe radiator system. The main objective of the SHARE experiment is to demonstrate suitable 0 g heat transfer performance of a 50 ft-long high-capacity monogroove heat pipe radiator element being developed for possible Space Station application. All of the flight certification tests were achieved, including a maximum heat rejection of 2 kW and thawing of a frozen heat pipe; and uninterrupted operation under cycling environmental and evaporator heat loads. Author

A86-40502
GEOSTATIONARY PLATFORM - AN APPLICATION OF THE SPACE STATION
K. L. ROSE (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 1-1 to 1-10.

Aggregate communication payloads developed in the NASA LeRC study are presented, and platform bus concepts currently evolving in the NASA MSFC study are described. The payloads encompass varying mixes of FSS, DBS, and maritime mobile services, WARC region 2, intraregion 2, and CONUS Intelsat traffic into the Atlantic and Pacific Ocean regions. The major features of four representative payload scenarios as developed by Ford Aerospace are described: (1) Scenario II, an FSS satellite with DBS capability, contains conventional C- and Ku-band transponders with two times frequency reuse at C-band and three times frequency at Ku-band; (2) Scenario IV is a high capacity, high power video distribution satellite; (3) Scenario V has CONUS coverage, and can be described as a high capacity CONUS, FSS satellite payload that is designed to address the distributional characteristics of CONUS traffic; and (4) Scenario VI-A, is the first of a complementary pair of satellites designed to handle all of the WARC region 2 Intelsat traffic, intraregion 2 as well as AOR and POR traffic. It is noted that Scenarios II, IV and V can be accommodated by a platform requiring a single STS launch while that accomodating Scenario VI-A requires multiple launches. K.K.

A86-40515* Alabama Univ., Huntsville.
AN ORBITAL MANEUVERING VEHICLE SIMULATOR
W. TEOH, J. WALLS (Alabama, University, Huntsville), T. BRYAN, F. ROE (NASA, Marshall Space Flight Center, Huntsville, AL), and N. SHIELDS (Essex Corp., Huntsville, AL) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 6-14 to 6-23.

The Orbital Maneuvering Vehicle (OMV) is a teleoperated vehicle designed to dock with a target vehicle in space to peform certain tasks. This vehicle is not yet in production, but a simulator of the OMV is located at Marshall Space Flight Center (MSFC). The MSFC facility provides a realistic simulation of the OMV. Various docking maneuvers can be studied in some detail. A special robot has been constructed that provides a moving target for the simulator to dock with. This facility is valuable for conducting studies on the OMV; it also is excellent for personnel training. Author

A86-40592#
EXPLORING AUTONOMY - THE T(2)C(2) SYSTEM
T. TURNER (Gulton Industries, Inc., Data Systems Div., Albuquerque, NM) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 111-117. refs
(AIAA PAPER 86-1184)

The functions of command and data handling systems are described. The command and telemetry system is applicable to satellites, rockets, satellite propulsion stages, experimental platforms, planetary exploration vehicles, and Space Stations. The benefits provided by an autonomous system and the implementation of autonomy in the areas of health and welfare maintenance are discussed. The architecture and capabilities of the Telemetry, Timing Command, and Control system, which is a spacecraft whose command and telemetry system is designed to

facilitate the design of an autonomous spacecraft, is examined. On-board processing is integrated into this system; three methods of integration are proposed. The use of fault tolerance, defined by fault detection, diagnosis, and correction, to satisfy the system's reliability requirements is studied. I.F.

A86-40593*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RESULTS OF THE ACCESS SPACE CONSTRUCTION SHUTTLE FLIGHT EXPERIMENT
W. L. HEARD, JR., J. J. WATSON (NASA, Langley Research Center, Hampton, VA), J. L. ROSS, S. C. SPRING, and M. L. CLEAVE (NASA, Johnson Space Center, Houston, TX) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 118-125. refs
(AIAA PAPER 86-1186)

The ACCESS (Assembly Concept for Construction of Erectable Space Structure) experiment was launched on the Orbiter Atlantis on November 26, 1985. ACCESS was designed to study manual assembly of a 45-foot long truss structure by two astronauts working in space suits in the Orbiter cargo bay. This paper describes the experiment and hardware used, and compares on-orbit construction timelines to underwater neutral buoyancy data. In-flight photographs of assembly tasks and comments made by the crew at the postflight debriefing are also included. It was found that all tasks could be accomplished and that assembly times compared favorably with neutral buoyancy data. Author

A86-40609*# National Aeronautics and Space Administration, Washington, D.C.
SPACECRAFT TECHNOLOGY REQUIREMENTS FOR FUTURE NASA MISSIONS
W. R. HUDSON (NASA, Washington, DC) and E. V. PAWLIK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 9 p. refs
(AIAA PAPER 86-1160)

Missions selected by NASA as representative of the most critical technology issues are described and the key technology requirements are discussed. The following are considered: (1) the Large Deployable Reflector (LDR), (2) the Sample Return Missions (SRM), (3) the Earth Observing System (EOS), and (4) the Geostationary Communications Platform (GCP). The LDR, designed for infrared and submillimeter astronomical measurements, will contain the following components for its instruments: indium antimonide charge-coupled arrays, extrinsic photodetector arrays, and heterodyne photoconductors. New technology developed for SRM includes an X-band transponder, a fiber-optic rotation sensor, and long-life batteries. The EOS will consist of instruments designed to measure the earth's atmosphere, interior, and surface, as well as an information system to support scientific research. Inherent in the platform of the GCP is the ability to effectively utilize both the geostationary arc and the electromagnetic spectrum; the GCP can also reduce overall satellite communications system costs. K. K.

A86-40616*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FUTURE SPACE TRANSPORTATION OPTIONS - OVERVIEW
P. F. HOLLOWAY (NASA, Langley Research Center, Hampton, VA) and W. F. H. ZERSEN (USAF, Space Div., Los Angeles, CA) AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 16 p.
(AIAA PAPER 86-1210)

A comprehensive consideration of space transportation system design possibilities and capabilities has noted that the U.S. (NASA and Department of Defense) launch vehicle users may enter the post-1995 period with a high operating cost space transportation architecture, primarily consisting of a small Space Shuttle fleet and its Complementary Expendable Launch Vehicle for unmanned operations. On the other hand, many technologies critical to the future of space transportation could yield substantial benefits in the post-1995 period. Current funding levels are expected to inhibit the timely development of many such technologies, however, and many current development programs have narrow and short term objectives that will not yield a cohesive data base for further development. O.C.

A86-40618*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ASSESSMENT OF INTERNATIONAL PAYLOAD REQUIREMENTS ON THE DUAL KEEL SPACE STATION - A SYSTEMS ANALYSIS CAPABILITIES EXAMPLE
C. L. ALLEN and G. C. ANDERSEN (NASA, Langley Research Center, Hampton, VA) AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 10 p. refs
(AIAA PAPER 86-1226)

In the early stages of spacecraft conceptual design, an investigation of subsystem requirements and their impacts on the total system provides insight into many aspects of the spacecraft design. Such an analysis has been performed on the dual keel space station to examine the system effects contributed by three international payloads provided by the Canadian, Japanese, and European Space Agencies. This example is used to illustrate some capabilities of available computer-driven tools and methods for a system analysis. Two space station configurations were examined, one without international payloads (the baseline configuration for the study) and one with the three international payloads. Each configuration was evaluated to define viewing limitations, rigid body dynamics and controls, structural dynamics, orbit lifetime, environmental control and life support, and thermal management effects. The performance, based on each subsystem evaluation, was then compared for the two configurations, and the results and recommendations are presented. Author

A86-41154* Alabama Univ., Huntsville.
COMMERICAL USE OF SPACE - STATUS AND PROSPECTS
C. A. LUNDQUIST (Alabama, University, Huntsville) and W. C. SNODDY (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Winter National Design Engineering Show and Conference, Anaheim, CA, December 11-13, 1985, Conference Talks . Stamford, CT, Cahners Exposition Group, 1985, p. 225-239. refs

The development of commercial enterprises in space is discussed. The convenience and cost-effectiveness of satellites for communications are examined; satellite communications is an established industry and continues to grow. Meteorological satellites and remote sensing satellite systems (Landsat and SPOT) are being utilized to collect earth resources data. The development of materials processing facilities in space is studied. Current and proposed systems for transporting payloads to space and space lab facilities are investigated. The advantages a space station will provide to communications, earth resources, and materials processing are analyzed. The role of governments in the commercialization of space is described. I.F.

A86-41679
NASA FINDS THE WAY TOWARD BUILDING A STATION FRAUGHT WITH LEGAL HURDLES
J. W. ANDERSON (Wilson, Elser, Moskowitz, Edelman, and Dicker, New York) Commercial Space (ISSN 8756-4831), vol. 2, Spring 1986, p. 57, 59-61.

Political and legal questions concerning the financing, design, and use of the Space Station by the Europeans, Japanese, Canadians, NASA, and the Defense Department are addressed. Disagreements include the Europeans' desire for a free-flying material processing module, and the Japanese wish for 70 percent of their on-board activities to be proprietary. The development of 'astrolaw' to determine a space criminal code, and the need for the presence of an astrolawyer to arbitrate conflicts among the various groups and individuals, are discussed. Though the Defense Department maintains that it has no use for the Space Station, its increasing role in U.S. space activities, as evidenced by the announcement of the X-31 spaceplane, and its space budget of twice that of NASA, suggest its possible involvement in the future.

Final agreement on the Station is not expected before the spring of 1987. R.R.

A86-41747*# Massachusetts Inst. of Tech., Lexington.
SATELLITE DEBRIS - RECENT MEASUREMENTS
L. G. TAFF (MIT, Lexington, MA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 342-346. NASA-sponsored research. refs
(Contract F19628-85-C-0002)

More frequent reports concerning orbital debris damage to spacecraft have prompted the design, development and testing of equipment and techniques for the observation of moving objects by passive optical means. A consolidation is presently made of hundreds of hours of space debris observation, quantifying the numbers of small bodies in space relative to the actively watched artificial satellite population and estimating the numbers of detectable objects from near-earth orbit to geostationary orbit distances. The debris reported constitutes 11 times the tracked population in near-earth orbit and between 25 and 50 percent of the deep space population. O.C.

A86-43228* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
POLAR PLATFORM PAYLOAD REQUIREMENTS IN THE 1990'S
D. VANE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) and M. DONOHOE (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 519-528. NASA-sponsored research. refs
(AAS PAPER 85-396)

NASA's Earth Orbiting System (EOS) and NOAA's operational payloads represent two of the major users of the Space Station Polar Platform capabilities. The EOS program will be designed for Shuttle launch, servicing and on-orbit augmentation, while the NOAA's payload will be designed for the operational monitoring of the earth's atmosphere, oceans, and land masses. An overview is given of both the EOS and NOAA platform programs as well as the implied platform requirements. It is concluded that the generic platform design must be capable of operating at altitudes ranging from Shuttle altitudes to NOAA altitudes (approximately 850 km). In addition, it must be able to accommodate approximately 5000 kg of payload mass, provide 5000 W of continuous power and up to 13 kW of peak power for short durations, and store and transmit data at rates up to 300 Mbps. K.K.

A86-43231* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLATFORM OPTIONS FOR THE SPACE STATION PROGRAM
M. J. MANGANO and R. W. ROWLEY (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 569-592. NASA-supported research. refs
(AAS PAPER 85-399)

Platforms for polar and 28.5 deg orbits were studied to determine the platform requirements and characteristics necessary to support the science objectives. Large platforms supporting the Earth-Observing System (EOS) were initially studied. Co-orbiting platforms were derived from these designs. Because cost estimates indicated that the large platform approach was likely to be too expensive, require several launches, and generally be excessively complex, studies of small platforms were undertaken. Results of these studies show the small platform approach to be technically feasible at lower overall cost. All designs maximized hardware inheritance from the Space Station program to reduce costs. Science objectives as defined at the time of these studies are largely achievable. Author

A86-43259
ORBIT MANOEUVRE AND DETERMINATION STRATEGY FOR THE EURECA MISSION
J. M. DOW and R. MUGELLESI (ESA, European Space Operations Centre, Darmstadt, West Germany) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 2 . San Diego, CA, Univelt, Inc., 1986, p. 1077-1098. refs
(AAS PAPER 85-408)

EURECA (EUropean REtrievable CArrier) is a reuseable platform which will be deployed and retrieved by the Shuttle. The paper describes manoeuvre and orbit determination strategies which have been developed to meet the requirements of the EURECA payload and those imposed by NASA retrieval policy. The initial altitude of the operational orbit is selected in such a way as to minimise the expected overall fuel usage for the mission. Optimisation of maneouvres based on a medium thrust level of 70 N has been studied. The accuracy feasible for orbit determination and prediction has been analysed for the most important phases of the mission and an error propagation made through the ascent and descent manoeuvres. A strategy is proposed for the manoeuvres which are to be performed during a period of one month prior to, and 2 to 3 days following the Shuttle launch. Author

A86-43337* National Aeronautics and Space Administration, Washington, D.C.
AMERICAN EXPERIENCES AND PERSPECTIVES - INTERNATIONAL COOPERATION ON A PERMANENTLY MANNED SPACE STATION
K. S. PEDERSEN (NASA, Washington, DC) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 27-32.

In the late 1960s, NASA contemplated the establishment of a permanently manned Space Station along with the development of the Space Shuttle. After a temporary postponement of the Space Station project, it was finally decided to develop a Space Station and to have it operating by the early 1990s. This station is to serve in a variety of functions which are important for further advances with respect to the utilization of space. The Space Station could even serve as a staging base for trips to the moon and visits to Mars. An international approach is to be taken regarding the development and utilization of the Space Station, giving attention to a cooperation of the U.S. with Canada, Europe, and Japan. The implementation of such a cooperation requires that a number of problems are solved. Basic approaches suitable for achieving such a solution are discussed, taking into account the development of operational schemes which provide for efficient management, while permitting the exercise of diverse 'ownership' rights. G.R.

A86-43650
THE EXPLOITATION OF SPACE: POLICY TRENDS IN THE MILITARY AND COMMERCIAL USES OF OUTER SPACE
M. SCHWARZ, ED. and P. STARES, ED. London and Stoneham, MA, Butterworth, 1985, 182 p. No individual items are abstracted in this volume.

Current developments and planning for the military and commercial exploitation of near-earth and outer space are examined critically from a global perspective in contributions to a revised and updated version of the survey of Schwarz and Stares (1982). Chapters are devoted to the evolution of space flight from Sputnik to the present, the transition from passive support to active weapons systems in the military use of space, civilian space exploitation, space industrialization, telecommunications, space as a potential future battlefield, problems of and prospects for the U.S. Strategic Defense Initiative, space stations, the relatively low availability of space exploitation to third-world nations, and alternative space futures. Maps, drawings, diagrams, and tables of numerical data are provided. T.K.

A86-43705
OLYMPUS, THE SPACECRAFT OF THE FUTURE
D.N. GREGORY (British Aerospace, PLC, Stevenage, England) IN: SPACECOM '85; Space and Radiocommunications Symposium, 5th, Paris and Le Bourget, France, June 5-7, 1985, Speakers' Papers . Geneva, Switzerland, International Telecommunication Union, 1985, p. 53-59.

The Olympus communications satellite development program of the European Space Agency is reaching the manufacturing stage, with the object of launching the first flight model in the latter half of 1987. The paper describes the main features of the program, and the spacecraft itself. It continues with a review of the experimental program, and concludes with a discussion of the development potential of the Olympus platform. Author

A86-44402
SPACE STATION - THE NEW FRONTIER
E. VALLERANI (Aeritalia S.p.A., Turin, Italy) Space Policy (ISSN 0265-9646), vol. 2, May 1986, p. 95-98.

It is pointed out that the Space Station currently under design in the U.S. will constitute the breakthrough for a new frontier: the space environment. Developments regarding the Space Station since the U.S. decision concerning its establishment are examined, taking into account agreements between NASA and ESA to coordinate studies conducted on both sides of the Atlantic, the type of cooperation considered, a package proposed by ESA regarding Columbus, and a certain dilemma related to issues regarding 'cooperation versus autonomy'. Attention is given to the reasons which make a European participation in the development and operation of the Space Station necessary, the idea that Europe would provide an integrated pressurized module, studies performed by an Italian firm under ESA contracts, and the challenge represented by the concept of a U.S.-European cooperation in the case of the Space Station. G.R.

A86-44405* National Aeronautics and Space Administration, Washington, D.C.
THE CHANGING FACE OF INTERNATIONAL SPACE COOPERATION - ONE VIEW OF NASA
K. S. PEDERSEN (NASA; Georgetown University, Washington, DC) Space Policy (ISSN 0265-9646), vol. 2, May 1986, p. 120-137. refs

It is pointed out that from its earliest years NASA has incorporated international participation into many of its programs. Guidelines were developed with the objective to maximize the benefits of international cooperation. The cooperative guidelines were accepted because they reflected conditions which applied during much or all of the 1960-1980 period. There existed a clear technology and experience gap between the U.S. and even its largest cooperative partners. Thus, the U.S. enjoyed a virtual Free World monopoly on launching large satellites, especially those destined for geostationary or interplanetary orbits. However, on the basis of new developments, NASA faces now a modified international operating environment, in which the U.S. technological lead has been significantly reduced. The results of this situation are examined, taking into account the equalization of capabilities, the rise of commercial competition, Soviet competition, multinational patterns, and reduced cooperative opportunities. G.R.

A86-44528* National Aeronautics and Space Administration, Washington, D.C.
JOINING FORCES IN SPACE - NASA'S VIEW
K. S. PEDERSEN (NASA, Washington, DC) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 1-4.

The NASA history of international cooperation is briefly reviewed. The evolving nature of the international space environment is discussed. The proposed international Space Station is described as an example of the continuing cooperative spirit and of the need to adapt to changed circumstances as they arise. Author

A86-44529* National Aeronautics and Space Administration, Washington, D.C.
NASA'S SPACE STATION PLANNING - AN UPDATE
F. T. HOBAN (NASA, Office of Space Station, Washington, DC) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 5-15.

The Manned Space Station (MSS) program is summarized, along with the program guidelines, activities, plans, management approach, international involvement and the present and future private sector role in space. The MSS, the first continually-manned facility in space, will be configured to grow modularly to meet future needs. Comprising both manned and unattached unmanned elements, the program is to advance the state of robotics and automation. Numerous uses of the MSS have been defined in support of and as the primary platform for astronomical observations, experimentation on prototype space-based industrial processes, and as a staging area for the launch and refurbishment of spacecraft. Current studies are targeted at defining the final design of the initial operating configuration, the hardware to be developed by the nations and organizations which are sharing in the work, and developing interest among potential commercial users of the MSS capabilities. M.S.K.

A86-44530
STATUS OF ESA'S PLANNING FOR THE SPACE STATION
G. ALTMANN (ESA, Manned and Retrievable Systems Dept., Noordwijk, Netherlands) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 17-33.

The present status of preparation for the European Space Station Programme (COLUMBUS) is reviewed. A description of the COLUMBUS Programme concept placed in the context of ESA's long term space plane is presented and all facets of the COLUMBUS Preparatory Programme are outlined to provide an overview of ESA's planning for the Space Station Programme. Author

A86-44531
SPACE PLATFORM DESIGN OPTIONS - A COMPARISON, FOR COST-EFFECTIVENESS, OF EXPENDABLE, REUSABLE AND SERVICEABLE SPACECRAFT
J. A. VANDENKERCKHOVE (ESA, Paris, France) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 45-68. refs

Various operational scenarios are considered, along with their required hardware infrastructures, the associated costs, and applications for unmanned orbiting platforms in the era of the Manned Space Station (MSS). The use of unmanned platforms as part of the MSS complex will compete with expendable satellites, retrievable/reusable satellites an serviceable satellites. The selection of which capability to use for any particular purpose will be the cost-effectiveness. A polar-orbiting platform is expected to carry 5 instruments and function for a 10 yr lifetime, after which only 30 percent of the payload will have to be replaced, probably by personnel orbited by either STS or Hermes launch or by an orbiting service vehicle. Comparisons are made among the expected serviceable lifetimes relative to the costs for launch and/or retrieval by the Ariane 5, Hermes, in-orbit assembly and STS. M.S.K.

A86-45627
THE EUROPEAN SPACE STATION PROGRAMME
M. BIGNIER (ESA, Paris, France) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 3-6.

After reaching agreements at the ministerial level, ESA in 1985 began negotiations with NASA to define the European role in the MSS Phase B design effort. Prime European goals were equal access and sharing of all facilities, equitable cost-sharing, satisfactory security measures, and compatibility with future ESA space transportation systems. Configurations considered by ESA

include the Columbus pressurized module, Space-Station co-orbiting and polar orbiting platforms, and a pressurized resources module. The tasks which ESA negotiators and technicians face in order to meet the MSS project schedule, to finalize the hardware plans and to ensure compatibility with other MSS systems are delineated. M.S.K.

A86-45628
THE COLUMBUS PROGRAMME CONCEPT AND ITS INITIAL IMPLEMENTATION STEPS
G. ALTMANN (ESA, Manned and Retrievable Systems Dept., Noordwijk, Netherlands) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 7-12.

The present status of the preparations for the European Space Station Programme (Columbus) is reviewed. Starting off with a description of the Columbus Programme concept and baselines, the paper then presents the major features of the Columbus preparatory programme which will be carried out in two steps, Phase B1 between June 1985 until March 1986 and Phase B2 between April 1986 and spring 1987, in cooperation with NASA. Author

A86-45629
TECHNOLOGY CHALLENGES FOR THE COLUMBUS PROGRAMME
M. TRELLA (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 17-20.

ESA participation in the NASA Manned Space Station (MSS) project is accelerating the development of indigenous European Technologies and facilities which were only partially required for the Spacelab effort. The MSS project requires hardware for extensive demonstration flights before implementation and detailed plans for future expansion. The technology programs comprise manned, platform and resources, and in-orbit operations elements. The manned element includes technologies for data management and information systems, structures and materials, environmental control and life support, electrical power management, and human factors. The platform and resources technologies cover thermal control, power generation, distribution and storage, attitude and orbit control, and data acquistion and communication. In-orbit operations comprise servicing, maneuvering and propulsion, and rendezvous and docking. Details of each of the program elements, along with their ESA funding breakdown, are provided. M.S.K.

A86-45630
US STATUS OF SPACE STATIONS PHASE B ACTIVITIES
J. AARON (JSP, Houston, TX) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 21-23.

Phase B efforts for the Manned Space Station (MSS) project in mid-1985 are described, along with activities to follow in the succeeding 9 mos. Phase B is formal systems definition and is projected to require 21 mos of work comprising the identification of options, evaluations and selections, carried out by NASA centers and internationally. An Engineering Master Schedule has been defined on the basis of trends that emerged in analyses of proposed configurations, operations and missions. The Schedule is intended in part to force convergence of the various proposed configurations. The design options thus far adopted are a solar power tower and a minimum of 37.5 kW power for a crew of four, increasing to 105 kW for a crew of 12. Cost estimates are also to be determined in Phase B. M.S.K.

A86-45637* National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION UTILIZATION
W. RANEY (NASA, Office of Space Station, Washington, DC) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 65-68.

Progress in the definition of Manned Space Station (MSS) capabilities and operations as of June 1985 is assessed in terms of the user requirements and engineering decisions. Input for making design and performance envelope decisions has come from various NASA offices, the NOAA, ESA and Japan. NASA, in coordinating the planning, is incorporating as much flexibility as possible to accommodate unforeseen requirements of the various participants. The decisions extend to the co-orbiting and polar orbiting platforms that are actually integral parts of the MSS concept. The rapid identification of uses of the MSS and man-tended platforms has defined sufficient uses to surpass the STS launch capabilities in the late 1990s and projected data recording capabilities. Other activity requests to-date have included 400 hr of EVA, 120 kW solar power input and six Orbital Maneuvering Vehicle missions the first year of operation. M.S.K.

A86-45641* National Aeronautics and Space Administration, Washington, D.C.
POINT OF VIEW OF THE U.S. SCIENCE COMMUNITY
D. C. BLACK (NASA, Washington, DC) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 91-93.

A special task force was formed by the National Academy of Sciences to examine the applications of Manned Space Station (MSS) platforms, communications and information systems, MSS operations and satellite assembly and repair capabilities on seven areas of space research. The task force reached several conclusions, including comprehensive space science planning by NASA with the MSS being one element of the plan. The STS is to provide a test bed for space research technologies and its basic design should be studied for conversion to an extended duration flight vehicle. The MSS could be categorized as a national facility, and payloads should be developed which specifically take advantage of its capabilities. The repair and maintenance capabilities which the MSS will furnish are concluded to be a significant asset to any future space science activities, and participation in those activities by the international science community is to be encouraged. M.S.K.

A86-45642
VIEWING THE EARTH FROM SPACE - TOWARDS THE SPACE STATION POLAR PLATFORM
D. L. CROOM and D. T. LLEWELLYN-JONES (SERC, Rutherford Appleton Laboratory, Didcot, England) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 97-100.

Current and proposed remote sensing techniques that may be used on the Manned Space Station (MSS) polar orbiting platforms to characterize various terrestrial phenomena are reviewed. The instruments operate in either passive or active modes, performing limb, nadir or side scanning operations to produce imagery with details ranging from 10-1000 m for high resolution to 10-100 km for low resolution. The sensor platforms are used for atmospheric, climate, ocean and ice and earthquake research, hydrology, to characterize biochemical cycles, for geophysics, etc. The polar orbits will provide access to scenes out of reach of the MSS orbit. The use of platforms will permit periodic visits, repairs, refurbishments and retrieval of the instruments. Over 12 platforms have been proposed for the initial operating configuration. The number will be significantly reduced to eliminate redundancy and to fit available launch schedules, which may permit on-station visits spaced no less than 2 yr apart. M.S.K.

A86-45647
FRENCH VIEWS ON COLUMBUS - PREPARATION OF ITS UTILIZATION RELATIONS WITH OTHER PROGRAMS
A. PERARD (CNES, Direction des Programmes, Paris, France) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 117-119.

A86-45709#
TECHNOLOGY BASE FOR THE FUTURE OF SPACE
R. A. DAVIS Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 44-47.

A summary is given of the detailed report of the AIAA's Ad Hoc Technical Committee on Space Systems, presented in November 1985 to the National Commission on Space. Among the key technologies detailed in the AIAA report that were highlighted by the Commission are high-performance electric propulsion systems, processing of lunar and other nonterrestrial materials, autonomous fault-tolerant machinery, aerospaceplane propulsion, advanced rocketry, aerobraking, long-duration closed ecosystems, nuclear-electric power plants, space tethers, and high-performance materials. Themes for civil space agendas are considered: cooperative international ventures, space commercialization, manned space stations leading to the protocolony, a Moon base, a Mars base during the third decade of the next century, and development and refinement of all the necessary support technologies. Author

A86-45767#
THE SPACE SETTLEMENT PAPERS
E. M. JONES (Los Alamos National Laboratory, NM), P. W. QUIGG, and J. I. GABRYNOWICZ British Interplanetary Society, Journal (Interstellar Studies) (ISSN 0007-084X), vol. 39, July 1986, p. 291-311.

The Space Settlement Papers are a written submission to the National Commission on Space appointed by President Reagan in April, 1985 to consider long range goals for the American Space program. The papers broadly consider the cultural, political, moral and economic bases for permanent space settlement rather than the more narrowly technical issues of transportation and life support technology. Attention is given to the frontier experience history of Americans, the global political context, analogous Antarctic conditions, the potential contribution of the social sciences to space settlement, and commercial regulation and environmental issues. O.C.

A86-46947*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
SPACE STATION - AN INTEGRATED APPROACH TO OPERATIONAL LOGISTICS SUPPORT
G. J. HOSMER (NASA, Kennedy Space Center; Boeing Co., Cocoa Beach, FL) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 13 p.
(AIAA PAPER 86-2321)

Development of an efficient and cost effective operational logistics system for the Space Station will require logistics planning early in the program's design and development phase. This paper will focus on Integrated Logistics Support (ILS) Program techniques and their application to the Space Station program design, production and deployment phases to assure the development of an effective and cost efficient operational logistics system. The paper will provide the methodology and time-phased programmatic steps required to establish a Space Station ILS Program that will provide an operational logistics system based on planned Space Station program logistics support. Author

A86-46951#
SPACE STATION OPERATIONS IN THE TWENTY-FIRST CENTURY
G. R. BENNETT (McDonnell Douglas Astronautics Co., Houston, TX) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NY, Sept. 3-5, 1986. 10 p. refs
(AIAA PAPER 86-2328)

A model outlining the requirements for achieving manned space operations is presented. Several Space Stations, each serving specific functions are proposed for effective use of space. The components of the Stations are to be designed for modularity and flexibility. The advantages of a multi-Space-Station system are discussed. The transportation system necessary for accomplishing the proposed space operations is described. The implementations of robotics to assist in operations, due to a limit on crew size, and of a computer system to schedule the use of limited resources are examined. The effect of the National Aerospace Plane on Space Station operations is investigated. The participation of industry in Space Station operations is considered. I.F.

A86-46955#
MAINTAINING AND SERVICING A SPACE-BASED ORBITAL TRANSFER VEHICLE (OTV) AT THE SPACE STATION
J. W. MALONEY and L. R. PENA (General Dynamics Corp., Space Systems Div., San Diego, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 10 p.
(AIAA PAPER 86-2332)

A candidate space-based OTV (SBOTV) is described as well as the advantages inherent to space basing, the requirements for accommodating an SBOTV, candidate hangar/support equipment, turnaround operations options, selection and definition of the most economical turnaround operations at the Space Station and maintenance of an OTV at the Space Station (SS). OTV launching, servicing/maintenance, payload integration and retrieval comprise the various space operations to be performed. Alternative methods for performing the turnaround operations (i.e. EVA with teleoperations or teleoperations only) are investigated and it is shown that the 'teleoperation only' option fulfills the need for reducing the amount of EVA manhours while simultaneously reducing the total manhours for SBOTV turnaround at the Space Station. It is concluded that modularity, accessibility, standardization of interfaces, lightweight construction, and a proper balance between EVA and teleoperations/robotics activities are key to the successful performance of an OTV at the SS in the 1990s. Man's ability to react to unexpected situations, interpret results and modify operations in real time must also be taken advantage of. K.K.

A86-46956#
SPACE STATION SERVICES PROVIDED TO COMMUNICATIONS SATELLITES
T. J. SHESKIN (Cleveland State University, OH) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 4 p. refs
(AIAA PAPER 86-2333)

The role of the Space Station in future satellite communications is discussed. Satellite communications in the 21st century are to be provided by modular geostationary platforms. The interference problems and use of fiber optics are considered. The assembly and testing of the platforms on the Space Station are described. The use of orbital transfer vehicles based on the Station to launch the platforms into geostationary earth orbit is examined. Remote servicing of the platforms is to be performed with teleoperational servicing units which will also be located on the Space Station. I.F.

A86-46961#
AN ECONOMICS PERSPECTIVE OF THE 21ST CENTURY SPACE STATION
M. K. MACAULEY (Resources for the Future, Washington, DC) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 5 p. refs
(AIAA PAPER 86-2348)

This paper offers an admonition for effective Space Station growth in the next century. Short of ability either to forecast or influence levels of economic activity, there nonetheless remains one aspect of near-term station use that can be implemented by station planners and that has direct consequences for the longer term. This aspect is the role of pricing policy for station access and use. Pricing can be crucial in determining where technical change and new developments in station design and operation will be needed. Furthermore, if past experience with technical change in the use of nonpriced resources is a guide to the future (as with the geostationary orbit and electromagnetic spectrum), the absence of prices can invite the presence of stringent, costly technical rules to accommodate scarcity, as well as emotive debate. Given the large amount of international collaboration envisioned for the Space Station, efficient pricing established early on in the program may perpetuate the most objective long-run allocation of scarce station resources. Author

A86-47445#
DESIGN STUDY FOR A HIGH STABILITY LARGE CENTRIFUGE TEST BED
L. DEMORE, H. HAVLISCEK, N. ANDRIANOS, M. HARSHMAN, C. WOOLHEATER et al. IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 403-419. refs
(Contract F08635-84-R-0098)
(AIAA PAPER 86-2100)

A comprehensive design study of a large (120-inch radius) Centrifuge Test Bed was completed. During the study, several dynamic models were created to predict the G-stability of the system. A 6 degree-of-freedom Euler model was used to predict rigid body variations due to bearing motion, mass unbalance, and dynamic torque disturbances. The dynamic simulation of the control system produced total, instantaneous, rate variations due to sensor errors, command errors, and various torque disturbances. Structural displacements were determined by combining the results of a finite element model with an estimate of dynamic loading. Over the entire range of operating conditions, the predicted, instantaneous G-stability was calculated to be less than 5 ppm peak-to-peak. By using composite materials for the boom and magnetic suspension for the main axis, the calculated, instantaneous G-stability was less than 2 ppm peak-to-peak. Author

A86-47453*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
FLIGHT RESULTS FROM THE GRAVITY-GRADIENT-CONTROLLED RAE-1 SATELLITE
D. L. BLANCHARD (NASA, Goddard Space Flight Center, Greenbelt; Ford Aerospace and Communications Corp., College Park, MD) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 479-487. refs
(AIAA PAPER 86-2140)

The in-orbit dynamics of a large, flexible spacecraft has been modeled with a computer simulation, which was used for designing the control system, developing a deployment and gravity-gradient capture procedure, predicting the steady-state behavior, and designing a series of dynamics experiments for the Radio Astronomy Explorer (RAE) satellite. This flexible body dynamics simulator permits three-dimensional, large-angle rotation of the total spacecraft and includes effects of orbit eccentricity, thermal bending, solar pressure, gravitational accelerations, and the damper system. Flight results are consistent with the simulator predictions and are presented for the deployment and capture phases, the steady-state mission, and the dynamics experiments. Author

A86-47960*# RCA Astro-Electronics Div., Princeton, N. J.
SPACE STATION POLAR ORBITING PLATFORM - MISSION ANALYSIS AND PLANNING
P. A. MILLER (RCA, Astro-Electronics Div., Princeton, NJ) AIAA and AAS, Astrodynamics Conference, Williamsburg, VA, Aug. 18-20, 1986. 8 p. refs
(Contract NAS5-29400)
(AIAA PAPER 86-2178)

The Space Station Polar Orbiting Platform will be a serviceable spacecraft supporting a range of missions. The planning and analysis of these missions is investigated. The subjects of STS compatibility, rendezvous strategy, and requisite launch windows are addressed. General, as well as, two specific cases are detailed with respect to their incremental velocity requirements. Author

A86-48373
SPACE STATION EVOLUTION - THE UNCERTAINTY PRINCIPLE PREVAILS
C. BULLOCH Interavia (ISSN 0020-5168), July 1986, p. 779-782.

NASA planners have repeatedly reduced the scope of initial Space Station design concepts in order to realistically respond to financial stringencies. The number of U.S.-operated pressurized modules has been reduced to two, not counting the Space Station's logistics module. A decision has been made to rely on a solar dynamic electrical generation system based on a closed thermodynamic cycle that is powered by a solar concentrator-reflector. Attention is given to Canadian, European and Japanese plans for participation, and the ownership/legal status consequences that various collaborative arrangements can have. O.C.

A86-48451#
PROJECTIONS OF SPACE SYSTEMS OPPORTUNITIES AND TECHNOLOGIES FOR THE 2000 TO 2030 TIME PERIOD
New York, American Institute of Aeronautics and Astronautics, 1985, 101 p. refs

The present work is a report compiled by an Ad Hoc Committee of AIAA and subsequently presented to AIAA for submittal to the National Commission on Space. Particular emphasis is placed on the establishment of a technology base which would be crucial to civil space endeavors in the 2000-2030 time period. It considers the impact of technologically relevant events of the last five years, discusses future space system missions and opportunities, highlights critical technology developments, and outlines the steps necessary to the enhancement of the technology base over the next few decades. Space system technologies for the following areas are discussed in detail: information processing; guidance navigation and control; autonomy and automation; sensors; communications; materials; propulsion, power and energy; atmospheric flight; thermal management; environment; human support manufacturing; test and evaluation; and economics. K.K.

A86-49554*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE SPACE REFLECTOR TECHNOLOGY ON THE SPACE STATION
J. C. MANKINS, R. M. DICKINSON, R. E. FREELAND, and N. I. MARZWELL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 9 p. NASA-supported research. refs
(AIAA PAPER 86-2302)

This paper discusses the role of the Space Station in the evolutionary development of large space reflector technology and the accommodation of mission systems which will apply large space reflectors during the late 1990s and the early part of the next century. Reflectors which range from 10 to 100 meters in size and which span the electromagnetic spectrum for applications that include earth communications, earth observations, astrophysics and

solar physics, and deep space communications are discussed. The role of the Space Station in large space reflector technology development and system performance demonstration is found to be critical; that role involves the accommodation of a wide variety of technology demonstrations and operational activities on the Station, including reflector deployment and/or assembly, mechanical performance verification and configuration refinement, systematic diagnostics of reflector surfaces, structural dynamics and controls research, overall system performance characterization and modification (including both radio frequency field pattern measurements and required end-to-end system demonstrations), and reflector-to-spacecraft integration and staging. A unique facility for Space Station-based, large space reflector research and development is proposed. A preliminary concept for such a Space Station-based Large Space Reflector Facility (LSRF) is described. Author

A86-49563#
SPACE STATION - THE CANADIAN CONTRIBUTION
K. H. DOETSCH (National Research Council of Canada, Space Div., Ottawa) and T. H. USSHER (Spar Aerospace Ltd., Remote Manipulator Systems Div., Toronto, Canada) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986, Paper. 17 p.

The Canadian-supplied Mobile Servicing System (MSS), a contribution to the U.S. Space Station program, is described. The flight and ground hardware elements of this system are discussed, and the expected benefits from this international cooperative endeavor are briefly examined. The Mobile Servicing Centre (MSC) functions are listed along with the role of Canada as either user or supplier of various Space Station infrastructure functions. Canadian responsibilities in the servicing and hardware on the Space Station are given, and the MSS hierarchy is shown along with MSC system elements. C.D.

A86-49565#
THE ROLE OF COLUMBUS IN A FUTURE SPACE STATION SCENARIO
W. WIENSS (ERNO Raumfahrttechnik, GmbH, Bremen, West Germany) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986, Paper. 22 p.

The possible functions and necessary space infrastructure of the European Space Station and the Columbus Program are discussed with emphasis on the Man-Tended Freeflyer (MTFF). The envisioned MTFF configuration consists of a two-segment pressurized laboratory module couple to a resource module, and Ariane 5 has been baselined as the reference launch vehicle. Maintenance, servicing, and logistics supply for the MTFF will occur via Hermes and a special logistics module. An MTFF growth scheme leading towards a permanently manned freeflyer is discussed, and the scenario for the time period of 2000 and beyond also includes the availability of an orbital infrastructure to support the transportation systems, on-orbit assembly, and servicing activities, as well as the production of materials in space. R.R.

A86-50266*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIRTF AND THE SPACE STATION
M. W. WERNER and C. B. WILTSEE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 10 p. refs
(AIAA PAPER 86-2353)

An evaluation is made of the technical prospects and scientific goals of the Space IR Telescope Facility (SIRTF), whose telescope is of 1-m aperture and cryogenically cooled and will be able to improve on IRAS performance in such areas as wavelength coverage, spectral and spatial resolution, and sensitivity. Attention is given to the findings of an intensive review of the long-life SIRTF mission, with a view to new determinations on its orbit, scientific performance requirements, and baseline design concepts, as well as the ways in which it will employ elements of the NASA Space Station. O.C.

A86-50337#
CONCEPTS ON COLUMBUS FLIGHT OPERATIONS
M. GASS (DFVLR, Oberpfaffenhofen, West Germany) and H. KUMMER (ESA, European Space Operations Centre, Darmstadt, West Germany) IN: Towards Columbus and Space Station; Proceedings of the International Symposium, Bonn, West Germany, October 2-4, 1985 . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 129-144.

European participation in the U.S. manned Space Station (MSS) effort is part of a long range plan for an autonomous European space station. The Columbus is the first hardware element, and is to fly either connected-to or co-orbiting the MSS. Flight operations for the Columbus will have three phases: launch/assembly, verification, and mature operations. Wherever possible, Columbus flight operations are to be controlled from Europe, although as many real-time actions as possible are to be performed by the on-board crew, assisted by expert systems and a user-friendly environment. The assignment of on-board tasks will be heavily influenced by the country and company of origin of payloads. Docking operations will be handled by the flight crew. If the Eureca is involved, then the European crew will maneuver the free-flyer into position for pick-up by the Orbiter crew. Initially, the Europeans will access the TDRSS satellite system for communications until an ESA DRS system is in place. M.S.K.

A86-50338#
COLUMBUS TECHNOLOGY - STATUS AND PLANS
H. STOEWER (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: Towards Columbus and Space Station; Proceedings of the International Symposium, Bonn, West Germany, October 2-4, 1985 . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 169-206.

Current and needed technological developments are described for satisfying the requirements of the indefinite service life on-orbit design specifications of the Columbus segment of the Space Station. Phase B studies identified the flight suitability or at least the feasibility of various candidate technologies, which are to be further evaluated to arrive at a baseline design in Phase C/D studies. The criteria for the Phase C/D designs are low risk, compatibility with NASA/ESA interface standards, and fostering European development of subsystems, wherever possible. R&D efforts supporting the design studies are divided into three areas: manned elements, unmanned platforms and resources technologies, and in-orbit operations. Design options being explored for the data management and information systems, structures and materials, environmental control and life support, electrical power management, and crew systems and human factors technologies are summarized. M.S.K.

N86-24588# Space Command, Peterson AFB, Colo. Cost and Economic Analysis Div.
PRIMER ON OPERATING AND SUPPORT (O AND S) COSTS FOR SPACE SYSTEMS
R. H. LAMONTAGNE Sep. 1985 16 p Presented at the 19th Annual Department of Defense Cost Analysis Symposium, Leesburg, Va., 17-20 Sep. 1985
(AD-A162381) Avail: NTIS HC A02/MF A01 CSCL 14A

Currently, the most common space system is the satellite with its associated ground-based support facilities. However, other systems are currently being developed such as the Strategic Defense Initiative (SDI), Space Station, space based radar, anti-satellite weapon, and others. Our difficulty in the cost community is in developing O&S cost estimates for all these systems. As a result HQ Space Command/ACM is in the process of developing a primer on O&S costs for Space Systems. It is intended to provide some guidelines and fundamentals for estimating the O&S cost for space systems; to address the O&S costs associated with space systems; and to present methodologies and factors to estimate the O&S costs. An O&S cost element structure will be developed for space systems. The primer will result in providing cost visibility for space systems for developing budget and life cycle cost estimates and analyses. GRA

N86-24732*# Rockwell International Corp., Huntsville, Ala.
SPACE PLATFORM EXPENDABLES RESUPPLY CONCEPT DEFINITION STUDY Final Report, Jan. - Oct. 1985
Dec. 1985 116 p
(Contract NAS8-35618)
(NASA-CR-178819; NAS 1.26:178819; STS85-0174-ADD) Avail: NTIS HC A06/MF A01 CSCL 22B

NASA has recognized that the capability for remote resupply of space platform expendable fluids will help transition space utilization into a new era of operational efficiency and cost/effectiveness. The emerging Orbital Maneuvering System (OMV) in conjunction with an expendables resupply module will introduce the capability for fluid resupply enabling satellite lifetime extension at locations beyond the range of the Orbiter. This report summarizes a supplemental study to the original Phase A study and is presented as addenda to that study. Author

N86-24733*# Rockwell International Corp., Downey, Calif.
SPACE PLATFORM EXPENDABLES RESUPPLY CONCEPT DEFINITION STUDY. VOLUME 1: EXECUTIVE SUMMARY Report, Mar. - Dec. 1984
Dec. 1984 36 p 4 Vol.
(Contract NAS8-35618)
(NASA-CR-178820; NAS 1.26:178820; STS-85-0174-VOL-1)
Avail: NTIS HC A03/MF A01 CSCL 22B

NASA has recognized that the capability for remote resupply of space platform expendable fluids will help transition space utilization into a new era of operational efficiency and cost/effectiveness. The emerging Orbital Maneuvering System (OMV) in conjunction with an expendables resupply module will introduce the capability for fluid resupply enabling satellite lifetime extension at locations beyond the range of the Orbiter. This report summarizes a Phase A study of a remote resupply module for the OMV. Volume 1 is the executive summary. Author

N86-24734*# Rockwell International Corp., Downey, Calif.
SPACE PLATFORM EXPENDABLES RESUPPLY CONCEPT DEFINITION STUDY, VOLUME 2 Technical Report, Mar. - Dec. 1984
Dec. 1984 295 p 4 Vol.
(Contract NAS8-35618)
(NASA-CR-178821; NAS 1.26:178821; STS-85-0174-VOL-2)
Avail: NTIS HC A13/MF A01 CSCL 22B

NASA has recognized that the capability for remote resupply of space platform expendable fluids will help transition space utilization into a new era of operational efficiency and cost/effectiveness. The emerging Orbital Maneuvering System (OMV) in conjunction with an expendables resupply module will introduce the capability for fluid resupply enabling satellite lifetime extension at locations beyond the range of the Orbiter. This report summarizes a Phase A study of a remote resupply module for the OMV. Volume 2 represents study results. Author

N86-24735*# Rockwell International Corp., Downey, Calif.
SPACE PLATFORM EXPENDABLES RESUPPLY CONCEPT DEFINITION STUDY. VOLUME 3: WORK BREAKDOWN STRUCTURE AND WORK BREAKDOWN STRUCTURE DICTIONARY Technical Report, Mar. 1984 - Dec. 1984
Dec. 1984 13 p 4 Vol.
(Contract NAS8-35618)
(NASA-CR-178822; NAS 1.26:178822; STS-85-0174-VOL-3)
Avail: NTIS HC A02/MF A01 CSCL 22B

The work breakdown structure (WBS) for the Space Platform Expendables Resupply Concept Definition Study is described. The WBS consists of a list of WBS elements, a dictionary of element definitions, and an element logic diagram. The list and logic diagram identify the interrelationships of the elements. The dictionary defines the types of work that may be represented by or be classified under each specific element. The Space Platform Expendable Resupply WBS was selected mainly to support the program planning, scheduling, and costing performed in the programmatics task (task 3). The WBS is neither a statement-of-work nor a work authorization document. Rather, it is a framework around which to define requirements, plan effort, assign responsibilities, allocate and control resources, and report progress, expenditures, technical performance, and schedule performance. The WBS element definitions are independent of make-or-buy decisions, organizational structure, and activity locations unless exceptions are specifically stated. Author

N86-24875*# Martin Marietta Aerospace, Denver, Colo.
SATELLITE VOICE BROADCAST. VOLUME 1: EXECUTIVE SUMMARY Final Report, Apr. 1984 - Jun. 1985
E. E. BACHTELL, S. S. BETTADAPUR, J. V. COYNER, and C. E. FARRELL Nov. 1985 17 p refs
(Contract NAS3-24233)
(NASA-CR-175016; NAS 1.26:175016) Avail: NTIS HC A02/MF A01 CSCL 17B

An Executive Summary of the Satellite Voice Broadcast System Study designs are synthesized for direct sound broadcast satellite systems for HF-, VHF-, and Ku-bands. Methods are developed and used to predict satellite weight, volume, and RF performance for the various concepts considered. Cost and schedule risk assessments are performed to predict time and cost required to implement selected concepts. Technology assessments and tradeoffs are made to identify critical enabling technologies that require development to bring technical risk to acceptable levels for full scale development. Author

N86-24876*# Martin Marietta Aerospace, Denver, Colo.
SATELLITE VOICE BROADCAST. VOLUME 2: SYSTEM STUDY Final Report, Apr. 1984 - Jun. 1985
E. E. BACHTELL, S. S. BETTADAPUR, J. V. COYNER, and C. E. FARRELL Nov. 1985 261 p refs 2 Vol.
(Contract NAS3-24233)
(NASA-CR-175017; NAS 1.26:175017; MTR-85-556-VOL-2)
Avail: NTIS HC A12/MF A01 CSCL 17B

The Technical Volume of the Satellite Broadcast System Study is presented. Designs are synthesized for direct sound broadcast satellite systems for HF-, VHF-, L-, and Ku-bands. Methods are developed and used to predict satellite weight, volume, and RF performance for the various concepts considered. Cost and schedule risk assessments are performed to predict time and cost required to implement selected concepts. Technology assessments and tradeoffs are made to identify critical enabling technologies that require development to bring technical risk to acceptable levels for full scale development. Author

N86-25398*# National Aeronautics and Space Administration, Washington, D.C.
AN OVERVIEW OF EUROPEAN SPACE TRANSPORTATION SYSTEMS
R. E. LO Nov. 1985 31 p refs Transl. into ENGLISH of conf. paper "Europaeische Raumfahrt-Transportsysteme" presented at the DGLR Annual Conference, 1985 p 1-24 Conference held in Bad Godesberg, West Germany, 30 Sep. - 2 Oct. 1985 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-77683; NAS 1.15:77683; DGLR-85-100) Avail: NTIS HC A03/MF A01 CSCL 22A

With the completion of the launch rocket series Ariane 1 to 4, Europe will have reached the same capacity to transport commercial payloads as the USA has with the Space Shuttle and the kick stages which are presently operative. The near term development of these capacities would require Europe to develop a larger launch rocket, Araine 5. Further motivations for this rocket are access to manned spaceflight, the development of an European space station, and the demand for shuttle technology. Shuttle technology is the subject of research being done in France on the winged re-entry vehicle Hermes. Operation of the European space station Columbus will require development of an interorbital transport system to facilitate traffic between the various segments of the space station. All European space transportation systems will have to match their quality to that of the other countries involve in space flight. All areas of development are marked not

only by possible cooperation but also by increased competition because of increasing commercialization of space flight. Author

N86-25401*# Alabama Univ., University. Environmental and Energy Center.
PERSONNEL OCCUPIED WOVEN ENVELOPE ROBOT Progress Report
F. C. WESSLING 1 Jun. 1986 45 p refs
(Contract NAGW-847)
(NASA-CR-176832; NAS 1.26:176832) Avail: NTIS HC A03/MF A01 CSCL 22B

The use of nonmetallic or fabric structures for space application is considered. The following structures are suggested: (1) unpressurized space hangars; (2) extendable tunnels for soft docking; and (3) manned habitat for space stations, storage facilities, and work structures. The uses of the tunnel as a passageway: for personnel and equipment, eliminating extravehicular activity, for access to a control cabin on a space crane and between free flyers and the space station are outlined. The personnal occupied woven envelope robot (POWER) device is shown. The woven envelope (tunnel) acts as part of the boom of a crane. Potential applications of POWER are outlined. Several possible deflection mechanisms and design criteria are determined. E.A.K.

N86-25403# National Environmental Satellite Service, Washington, D. C.
PLAN FOR SPACE STATION POLAR-ORBITING PLATFORM Final Report
J. H. MCELROY, S. R. SCHNEIDER, D. B. MILLER, and J. W. SHERMAN, III Jun. 1985 105 p refs
(AD-A164405) Avail: NTIS HC A06/MF A01 CSCL 22B

This ENVIROSAT-2000 Report concerns utilization of the polar platform component of NASA's Space Station program. Issues covered in the report include instrument payloads, altitudes, orbits, serviceability, communications, and data processing. A scenario is set forth for operational utilization of the platform, including issues surrounding integration of operational and research missions. The discussion is broken down by discipline: oceanography, meteorology, land sciences, atmospheric sciences, and solar-terrestrial investigations. A cost analysis shows that performing NOAA operations from the polar platforms would prove extremely beneficial by replacing the expendable two Polar-orbiting Operational Environmental Satellite (POES) system that NOAA now maintains. GRA

N86-27146*# Indiana Univ. Northwest, Gary.
COSMIC DUST COLLECTION WITH A SUB-SATELLITE TETHERED TO A SPACE STATION
G. J. CORSO *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 2 p May 1986
Prepared in cooperation with Northwestern Univ., Evanston, Ill.
Avail: NTIS HC A05/MF A01 CSCL 03A

The number concentration and density of 1 micron and submicron sized grains in interplanetary space, as well as their relation to the larger zodical dust particles, and the importance of the Beta meteoroid phenomenon are currently being questioned. The best approach to collecting large numbers of intact micron and submicron sized cosmic dust particles in real time while avoiding terrestrial and man made contamination would be to employ a tethered subsatellite from a space station down into the Earth's atmosphere. Such a subsatellite tied to the space shuttle by a 100 km long tether is being developed. It is also possible that a permanent space station would allow the use of a tether even longer that 100 km. It should be noted that the same tethered collectors could also be employed to study the composition and flux of man made Earth orbiting debris in any direction within 100 km or so of the space station. B.G.

N86-27162*# Brown Univ., Providence, R. I. Dept. of Geological Sciences.
IMPACTS OF FREE-FLOATING OBJECTS: UNIQUE SPACE STATION EXPERIMENTS
P. H. SCHULTZ and D. E. GAULT (Murphys Center of Planetology, Calif.) *In* NASA. Lyndon B. Johnson Space Center Space STation Planetology Experiments (SSPEX) 2 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

The transfer of momentum and kinetic energy between planetary bodies forms the basis for wide ranging problems in planetary science ranging from the collective long term effects of minor perturbations to the catastrophic singular effect of a major collision. Although the collisional transfer of momentum and energy was discussed over the last two decades, major issues remain that largely reflect current limitations in Earth based experimental conditions and 3-D numerical codes. Two examples with potential applications in a Space Station laboratory, are presented: asteroid spin rates and orientations, and planetary disruption/spin rates. Asteroid spin rate and orientation experiments are needed wherein free floating nonspining and spining objects of varying strength, porosity, and volatility are impacted at varying velocities and angles. A space station platform also could provide an opportunity to test important facets of planetary disruption/spin rate models by allowing freely suspended spherical targets of varying viscosities, internal density gradients, and spin rates. Author

N86-27402*# RCA Astro-Electronics Div., Princeton, N. J.
COMMUNICATIONS PLATFORM PAYLOAD DEFINITION STUDY
H. W. CLOPP, T. A. HAWKES, C. R. BERTLES, B. A. PONTANO (Communications Satellite Corp., Clarksburg, Md.), and T. KAO Washington, D.C. NASA Jul. 1986 245 p
(Contract NAS3-24236)
(NASA-CR-174986; NAS 1.26:174986) Avail: NTIS HC A11/MF A01 CSCL 22B

Large geostationary communications platforms were investigated in a number of studies since 1974 as a possible means to more effectively utilize the geostationary arc and electromagnetic spectrum and to reduce overall satellite communications system costs. The commercial feasibility of various communications platform payload concepts circa 1998 was addressed. Promising payload concepts were defined, recurring costs were estimated, and critical technologies needed to enable eventual commercialization were identified. Ten communications service aggregation scenarios describing potential groupings of service were developed for a range of conditions. Payload concepts were defined for four of these scenarios: (1) Land Mobile Satellite Service (LMSS) meets 100% of Contiguous United States (CONUS) plus Canada demand with a single platform; (2) Fixed Satellite Service (FSS) (trunking + Customer Premises Service (CPS)), meet 20% of CONUS demand;(3) FSS (trunking + CPS + video distribution), 10 to 13% of CONUS demand; and (4) FSS (20% of demand) + Inter Satellite Links (ISL) + Tracking and Data Relay Satellite System (TDRSS)/Tracking and Data Acquisition System (TDAS) Data Distribution. Author

N86-27407*# RCA Astro-Electronics Div., Princeton, N. J.
COMMUNICATIONS PLATFORM PAYLOAD DEFINITION STUDY, EXECUTIVE SUMMARY
H. W. CLOPP, T. A. HAWKES, C. R. BERTLES, B. A. PONTANO (Communications Satellite Corp., Washington, D.C.), and T. KAO Jul. 1986 34 p
(Contract NAS3-24236)
(NASA-CR-174985; NAS 1.26:174985) Avail: NTIS HC A03/MF A01 CSCL 22B

Large geostationary communications platforms have been investigated in a number of studies since 1974 as a possible means to more effectively utilize the geostationary orbital arc and electromagnetic spectrum and to reduce overall satellite communications system costs. This NASA Lewis sponsored study addresses the commercial feasibility of various communications platform payload concepts circa 1998. It defines promising payload concepts, estimates recurring costs and identifies critical

technologies needed to permit eventual commercialization. Ten communications service aggregation scenarios describing potential groupings of services were developed for a range of conditions. Payload concepts were defined for four of these scenarios: (1) Land Mobile Satellite Service (LMSS), meet 100% of CONUS plus Canada demand with a single platform; (2) Fixed Satellite Service (FSS) (Trunking + Customer Premises Service (CPS), meet 20% of CONUS demands; (3) FSS (Trunking + video distribution), 10 to 13% of CONUS demand; and (4) FSS (20% of demand) + Inter Satellite Links (ISL) + TDRSS/TDAS Data Distribution.
Author

N86-27409*# National Aeronautics and Space Administration, Washington, D.C.
THE SUITABILITY OF VARIOUS SPACECRAFT FOR FUTURE SPACE APPLICATIONS MISSIONS
C. W. MATHEWS, R. BERNSTEIN (International Business Machines Corp., Palo Alto, Calif.), and D. C. MACLELLAN (Massachusetts Inst. of Tech., Cambridge.) Jul. 1986 18 p
(NASA-TM-88986; NAS 1.15:88986) Avail: NTIS HC A02/MF A01 CSCL 22B

The Space Applications Advisory Committee (SAAC) of NASA's Advisory Council was asked by the Associate Administrator for Space Science and Applications to consider the most suitable future means for accomplishing space application missions. To comply with this request, SAAC formed a Task Force whose report is contained in this document. In their considerations, the Task Force looked into the suitability of likely future spacecraft options for supporting various types of application mission payloads. These options encompass a permanent manned space station, the Space Shuttle operating in a sortie mode, unmanned platforms that integrate a wide variety of instruments or other devices, and smaller free fliers that accommodate at most a few functions. The Task Force also recognized that the various elements could be combined to form a larger space infrastructure. This report summarizes the results obtained by the Task Force. It describes the approach utilized, the findings and their analysis, and the conclusions.
Author

N86-28420*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TECHNOLOGY AND TEST
P. SIEMERS *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 279-283 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

The chairman of the Technology Applications in Space Working Group summarizes the technology issues for each of the disciplines in Tethered Satellite Systems. The disciplines are Tether Materials and Configurations, Tether System Dynamic Simulation Capability, Tether System Instrumentation, TAS Program Related Science Instrumentation, Atmospheric/Aerothermodynamic tethered system research, and TAS Discipline Program Accomplishment. To enable these tether applications, design and development programs have been recommended and are presently underway relative to the demonstration of the hollow cathode concept which is an enabling electrodynamic tether mission technology. E.R.

N86-28424*# Naples Univ. (Italy). Inst. of Gasdynamics.
HIGH RESOLUTION REMOTE SENSING MISSIONS OF A TETHERED SATELLITE
S. VETRELLA and A. MOCCIA *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 349-363 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

The application of the Tethered Satellite (TS) as an operational remote sensing platform is studied. It represents a new platform capable of covering the altitudes between airplanes and free flying satellites, offering an adequate lifetime, high geometric and radiometric resolution and improved cartographic accuracy. Two operational remote sensing missions are proposed: one using two linear array systems for along track stereoscopic observation and one using a synthetic aperture radar combined with an interferometric technique. These missions are able to improve significantly the accuracy of future real time cartographic systems from space, also allowing, in the case of active microwave systems, the Earth's observation both in adverse weather and at any time, day or night. Furthermore, a simulation program is described in which, in order to examine carefully the potentiality of the TS as a new remote sensing platform, the orbital and attitude dynamics description of the TSS is integrated with the sensor viewing geometry, the Earth's ellipsoid, the atmospheric effects, the Sun illumination and the digital elevation model. A preliminary experiment has been proposed which consist of a metric camera to be deployed downwards during the second Shuttle demonstration flight.
Author

N86-28970*# National Aeronautics and Space Administration, Washington, D.C.
PLANETARY EXPLORATION THROUGH YEAR 2000: AN AUGMENTED PROGRAM. PART TWO OF A REPORT BY THE SOLAR SYSTEM EXPLORATION COMMITTEE OF THE NASA ADVISORY COUNCIL
1986 240 p Original contains color illustrations
(NASA-TM-89235; NAS 1.15:89235) Avail: SOD HC $12.00 as 033-000-00987-9; NTIS MF A01 CSCL 22A

In 1982, the NASA Solar System Exploration Committee (SSEC) published a report on a Core Program of planetary missions, representing the minimum-level program that could be carried out in a cost effective manner, and would yield a continuing return of basic scientific results. This is the second part of the SSEC report, describing missions of the highest scientific merit that lie outside the scope of the previously recommended Core Program because of their cost and technical challenge. These missions include the autonomous operation of a mobile scientific rover on the surface of Mars, the automated collection and return of samples from that planet, the return to Earth of samples from asteroids and comets, projects needed to lay the groundwork for the eventual utilization of near-Earth resources, outer planet missions, observation programs for extra-solar planets, and technological developments essential to make these missions possible. M.G.

N86-30589*# Northwestern Univ., Evanston, Ill. Astronomical Research Center.
THE USE OF TETHERED SATELLITES FOR THE COLLECTION OF COSMIC DUST AND THE SAMPLING OF MAN MADE ORBITAL DEBRIS FAR FROM THE SPACE STATION
G. J. CORSO *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 52-53 1986 refs Prepared in cooperation with Loyola Univ., Chicago, Ill.
Avail: NTIS HC A06/MF A01 CSCL 03B

The use of a tethered subsatellite employed downward into the earth's upper atmosphere to an altitude of about 110 km above the earth would eliminate the orbital contamination problem while at the same time affording a measure of atmospheric braking to reduce the velocities of many particles to where they may be captured intact or nearly so with properly designed collectors. The same technique could also be used to monitor the flux of all types of man-made orbital debris out to a distance of more than a hundred kilometers in any direction from the space station. In this way the build up of any debris belt orbiting earth could be determined. The actual collecting elements used for both purposes could be of several different materials and designs so as to optimize the collection of different types of particles with different densities. Stacks of foils, films, plastics, and foams, as well as simple capture cells would be mounted in clusters around the outside of a tethered satellite and protected by iris covers until the tethered had been fully deployed. If the orientation history of the satellite were known the direction of the incoming material could be infered. A chief advantage in deploying such tethered collectors from the Space Station instead of from the shuttle is the ability to maintain deployment of the tether for days instead of hours resulting in much greater yields of intact particles and impact debris. M.G.

N86-30602*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION
D. R. THOMPSON *In* Lunar and Planetary Inst. IN Trajectory Determination and Collection of Micrometeoroids on the Space Station p 83-84 1986
Avail: NTIS HC A06/MF A01 CSCL 03B

The Space Station is being defined as a multi-purpose facility with emphasis in the following areas: scientific and technology research laboratory; permanent observatory; spacecraft servicing facility; construction and assembly facility; manufacturing facility; transportation node; and staging base for future space endeavors. The Station complex, in its initial operating capability configuration, includes a continuously habitable manned element, a polar orbiting unmanned platform, and a second unmanned platform co-orbiting with the manned element. All elements are dependent on the Space Transportation System (STS) for initial placement on-orbit and for subsequent logistical services. The manned element will be designed for long duration operations with systems maintainable on-orbit and operationally autonomous from ground control. A major feature of the Station will be its adaptability to evolutionary technology upgrades; and the Space Station, as a system, is to be designed for maximum ease of use by its users. Author

N86-30604*# Technische Univ., Munich (West Germany). Lehrstuhl fuer Raumfahrttechnik.
COSMIC DUST DETECTION WITH LARGE SURFACE PIEZOCERAMICS
U. WEISHAUPT *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 88-90 1986
Avail: NTIS HC A06/MF A01 CSCL 03B

Piezoelectric transducers mounted on targets made out of metal plates or plastic foils have been used in many former space missions to detect impacting dust particles and to determine some of their parameters (e.g., momentum). The proposed detector is based on a large disc made out of piezoceramic material. Dust particles impacting on the detector will cause electrical charge pulses due to the piezoelectric nature of the target material. These charge pulses are measured on the electrodes of the disc and transformed with a charge sensitive amplifier (CSA) to voltage pulses. Counting the number of pulses leads to the dust-flux impacting on the detector. Additionally the amplitude and the rise time of the pulse slopes are determinated to evaluate the momentum and the size of the dust particles. Due to the high charge production rate per force unit of piezoceramics and momentum transfer without loss the sensivity of this acoustic sensor is very high. A method to derive size and momentum from the rising slope of an acoustic signal is described. M.G.

N86-30933*# Foldes, Inc., Wayne, Pa.
A DESIGN STUDY FOR THE USE OF A MULTIPLE APERTURE DEPLOYABLE ANTENNA FOR SOIL MOISTURE REMOTE SENSING SATELLITE APPLICATIONS Final Report
P. FOLDES Aug. 1986 208 p
(Contract NAS1-17209)
(NASA-CR-178154; NAS 1.26:178154) Avail: NTIS HC A10/MF A01 CSCL 09A

The instrumentation problems associated with the measurement of soil moisture with a meaningful spatial and temperature resolution at a global scale are addressed. For this goal only medium term available affordable technology will be considered. The study while limited in scope, will utilize a large scale antenna structure, which is being developed presently as an experimental model. The interface constraints presented by a singel Space Transportation System (STS) flight will be assumed. Methodology consists of the following steps: review of science requirements; analyze effects of these requirements; present basic system engineering considerations and trade-offs related to orbit parameters, number of spacecraft and their lifetime, observation angles, beamwidth, crossover and swath, coverage percentage, beam quality and resolution, instrument quantities, and integration time; bracket the key system characteristics and develop an electromagnetic design of the antenna-passive radiometer system. Several aperture division combinations and feed array concepts are investigated to achieve maximum feasible performacne within the stated STS constraints. B.G.

N86-31637# Societe Nationale Industrielle Aerospatiale, Paris (France).
SPACEBUS: MULTIMISSION COMMUNICATION SATELLITES [SPACEBUS: SATELLITES DE TELECOMMUNICATION MULTIMISSIONS]
A. DAGUET 1986 5 p In FRENCH Presented at Journees Industrielles France-Canada, Ottawa, Ontario, 10-12 Sep. 1985
(SNIAS-861-422-119; ETN-86-97604) Avail: NTIS HC A02/MF A01

The Spacebus satellite system is described. The family includes three capacities (Spacebus 100 to 300). The characteristics are a modular design, three axis stabilization, unified two component propulsion and deployable solar generator. Output power is from 1400 W to 6000 W. The mass in synchronous orbit is from 650 kg to 1500 kg. Arabsat is an example of Spacebus 100 design. ESA

N86-32106# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
CONTROL THEORETIC ANALYSIS OF HUMAN OPERATOR MEDIATED RENDEZVOUS AND DOCKING
P. MILGRAM and P. H. WEWERINKE 26 Feb. 1985 10 p Presented at 2nd IFAC/IFIP/IFORS/IEA Conf. on Analysis, Design and Evaluation of Man-Machine Systems, Varese, Italy, 10-12 Sep. 1985
(NLR-MP-85020-U; B8661085; ETN-86-97669) Avail: NTIS HC A02/MF A01

A model based analysis of manual control of space rendezvous and docking in the presence of transmission time delays (nominal case: human operator (HO) on the ground) is presented. The variables studied are time delay, human induced motor noise levels, rotational and translational control and the effect of display prediction. An envelope of performance is estimated, bounded by performance with optimal prediction and performance with no prediction at all. Nominal performance for a simple second order Taylor predictor display is estimated. An HO imperfect internal representation of the system is used to model the no-predictor and predictor display cases. ESA

N86-32107# National Aerospace Lab., Amsterdam (Netherlands). Space Flight Div.
CONTROL LOOPS WITH HUMAN OPERATORS IN SPACE OPERATIONS. PART 1: HUMAN ENGINEERING ANALYSIS, SYNTHESIS AND EVALUATION TECHNIQUES Final Report
P. MILGRAM, R. C. VANDEGRAAFF, and P. H. WEWERINKE Paris ESA 17 May 1985 280 p
(Contract ESA-5594/83)
(NLR-TR-84116-L-PT-1; ESA-CR(P)-2190-PT-1; ETN-86-97787)
Avail: NTIS HC A13/MF A01

Human engineering approaches and methodologies applicable for analysis of performance of human-machine systems, particularly space teleoperator applications, are reviewed. Motivated by the presumed active role of the human operator in future space teleoperation missions, the application of human engineering within the various stages of system development is discussed, emphasizing the impact on the development cycle of being able to analyze various aspects of human-in-the-loop system performance. Experimental and theoretical approaches to human performance analysis are identified. Fundamental and practical aspects of each approach are outlined. A modeling approach for the analysis of a specific class of supervisory space teleoperator missions is proposed. Human-computer task allocation for such missions is considered. ESA

N86-32108# National Aerospace Lab., Amsterdam (Netherlands). Space Flight Div.
CONTROL LOOPS WITH HUMAN OPERATORS IN SPACE OPERATIONS. PART 3: RENDEZVOUS AND DOCKING OPERATIONS AND MODEL ANALYSIS OF PERFORMANCE WITH HUMAN-IN-THE-LOOP Final Report
P. MILGRAM, P. T. L. M. VANWOERKOM, and P. H. WEWERINKE Paris ESA 7 Dec. 1984 192 p
(Contract ESA-5594/83)
(NLR-TR-84116-L-PT-3; ESA-CR(P)-2190-PT-3; ETN-86-97789)
Avail: NTIS HC A09/MF A01

Human-in-the-loop rendezvous and docking (RVD) performance was analyzed to demonstrate the practicality of applying engineering methods and techniques to the analysis of control loops with human operators in space operations. The RVD space segment and the related autonomous operations are described. Model analyses of RVD performance in the final approach phase, for the case in which the human operator is involved in manual control of RVD, and for the case in which the human operator is monitoring an automated RVD for the occurrence of failures are given. ESA

N86-32109# National Aerospace Lab., Amsterdam (Netherlands). Space Flight Div.
CONTROL LOOPS WITH HUMAN OPERATORS IN SPACE OPERATIONS. PART 4: RESEARCH REQUIREMENTS FOR HUMAN-IN-THE-LOOP SPACE TELEOPERATOR DEVELOPMENT Final Report
P. MILGRAM Paris ESA 17 May 1985 62 p
(Contract ESA-5594/83)
(NLR-TR-84116-L-PT-4; ESA-CR(P)-2190-PT-4; ETN-86-97790)
Avail: NTIS HC A04/MF A01

Short-term human engineering research requirements for developing rendezvous and docking and space telemanipulation capabilities are presented. A catalog of research topics related to human-in-the-loop teleoperation performance is given. Available resources for model analytical investigation of these research topics and resources for the establishment of an initial human performance research laboratory for carrying out such investigations and for testing proposed design concepts by ESA are reviewed. ESA

N86-32110# National Aerospace Lab., Amsterdam (Netherlands). Space Flight Div.
CONTROL LOOPS WITH HUMAN OPERATORS IN SPACE OPERATIONS. PART 5: EXECUTIVE SUMMARY Final Report
P. MILGRAM Paris ESA 17 May 1985 157 p
(Contract ESA-5594/83)
(NLR-TR-84116-L-PT-5; ESA-CR(P)-2190-PT-5; ETN-86-97791)
Avail: NTIS HC A08/MF A01

Human engineering analysis, synthesis, and evaluation techniques; robotics operations and manual control experiments; spacecraft rendezvous and docking operations and model analysis of performance with human-in-the-loop; and ESA research requirements for human-in-the-loop space teleoperator development are discussed. ESA

N86-32504*# Boeing Aerospace Co., Kennedy Space Center, Fla.
ORBITAL TRANSFER VEHICLE LAUNCH OPERATIONS STUDY: MANPOWER SUMMARY AND FACILITY REQUIREMENTS, VOLUME 5 Final Report
7 Mar. 1986 36 p
(Contract NAS10-11165)
(NASA-CR-179705; NAS 1.26:179705) Avail: NTIS HC A03/MF A01 CSCL 22D

All manpower numbers, number of heads (by skill), serial time and manhours have been accumulated and compiled on a per subtask basis in spreadsheet format for both the ground based and the space based data flows. To aid in identifying the facility resources required to process the Ground Based Orbital Transfer Vehicle (GBOTV) and/or the space based orbital transfer vehicle (SBOTV) through the ground facilities at Kennedy Space Center (KSC), a software application package was developed using a general purpose data base management system known as Data Flex. The facility requirements are used as the basic input to this software application. The resources of the KSC facility that could be used by orbital transfer vehicle program were digitized in the same format used to identify facility requirements. The facility capabilities were digitized in this format for subsequent, automated comparative analyses. Composite facility requirements are compared to each of the baseline facility capabilities and the system generates a relative score that indicates how each facility weighs against the composite requirements in relation to the other facilities in the set. Author

N86-32505*# Boeing Aerospace Co., Kennedy Space Center, Fla.
ORBITAL TRANSFER VEHICLE LAUNCH OPERATIONS STUDY. PROCESSING FLOWS. VOLUME 3 Final Report
7 Mar. 1986 230 p
(Contract NAS10-11165)
(NASA-CR-179766; NAS 1.26:179766) Avail: NTIS HC A11/MF A01 CSCL 22D

The Orbit Transfer Vehicle (OTV) processing flow and Resource Identification Sheets (RISs) for the ground based orbit transfer vehicle and for the space based orbit transfer vehicle are the primary source of information for the rest of the Kennedy Space Center (KSC) OTV Launch Operations Study. Work is presented which identifies KSC facility requirements for the OTV Program, simplifies or automates either flow though the application technology, revises test practices and identifies crew sizes or skills used. These flows were used as the primary point of departure from current operations and practices. Analyses results were documented by revising the appropriate RIS page. B.G.

02

ANALYSIS AND DESIGN TECHNIQUES

Includes interactive techniques, computerized technology design and development programs, dynamic analysis techniques, environmental modeling, thermal modeling, and math modeling.

A86-32538*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ARTIFICIAL INTELLIGENCE - NASA
J. D. ERICKSON (NASA, Johnson Space Center, Houston, TX) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 145-150. refs

Artificial Intelligence (AI) represents a vital common space support element needed to enable the civil space program and commercial space program to perform their missions successfully. It is pointed out that advances in AI stimulated by the Space Station Program could benefit the U.S. in many ways. A fundamental challenge for the civil space program is to meet the needs of the customers and users of space with facilities enabling maximum productivity and having low start-up costs, and low annual operating costs. An effective way to meet this challenge may involve a man-machine system in which artificial intelligence, robotics, and advanced automation are integrated into high reliability organizations. Attention is given to the benefits, NASA strategy for AI, candidate space station systems, the Space Station as a stepping stone, and the commercialization of space. G.R.

A86-32553
ENVIRONMENTAL CRITERIA GUIDELINES FOR SPACE VEHICLE AND SPACE DESIGN
R. E. TURNER and W. FROST (FWG Associates, Inc., Tullahoma, TN) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 273-279.

The natural environment plays an important role in the design of space vehicles and systems to ensure the operational capabilities are met in an efficient and economical manner. It is necessary that the criteria be specified to agree with the operational requirements for the system under development. This paper discusses the philosophy used in the development of natural environment criteria and describes the two major criteria guidelines documents prepared to support the criteria development activities. Author

A86-32910#
DESIGN FOR SPACE DEBRIS PROTECTION
N. ELFER and G. KOVACEVIC (Martin Marietta Corp., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 14 p. Research supported by the Martin Marietta Independent Research and Development Program. refs

This paper reviews the process of designing a spacecraft to survive the space debris and meteroid environemnt. The effective exposed area, the flux and the exposure time can be used to determine the probability of impact. Due to the highly directional nature of orbiting debris, the actual surface area can be broken up and each increment should be multiplied by a flux factor according to its orientation to convert it to an effective surface area. The probability of penetration is then calculated from the probability of impact including oblique impact effects and low velocity penetration. New results are presented for the analysis of space debris shadowing effects; for the incorporation of low velocity penetration; and also for the penetration resistant properties of some composite materials. Composites have been tested as bumpers, and will be tested as intermediate shields and rear walls. Author

A86-35216
SPACE STATION DESIGN-TO-COST - A MASSIVE ENGINEERING CHALLENGE
M. C. SIMON (General Dynamics Corp., Space Systems Div., San Diego, CA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 11 p. refs
(SAWE PAPER 1673)

The Space Station, NASA's first major test of design-to-cost concepts, must include: (1) pressurized modules with habitat provisions for six crewpersons as well as space for laboratory and logistics functions; (2) a power system capable of generating 75 kilowatts of continuous power; and (3) unmanned platforms for conducting experiments that cannot be accommodated on the core facility. Beyond the implementation of these basic necessities, NASA and its contractors must adhere to a rigorous design-to-cost approach to SS design, development and production. Ultimately, size, shape and function of the SS will be determined by cost more than any single evaluation criterion. K.K.

A86-36866#
FINITE ELEMENT ANALYSIS OF SUBREGIONS USING A SPECIFIED BOUNDARY STIFFNESS METHOD
C. C. JARA-ALMONTE and C. E. KNIGHT (Virginia Polytechnic Institute and State University, Blacksburg) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 2 . New York, American Society of Mechanical Engineers, 1985, p. 407-411. refs

A new approach is presented to the problem of modeling subregions, important in order to accomplish finite element analysis of large, complex structures. The approach requires the specification of the stiffnesses and forces at the nodes on the boundary of the subregion model. These stiffnesses and forces would be those acting upon the subregion from the rest of the structure and would come from an analysis of the entire structure. Accurate displacement and stress solutions are obtained with this method because it takes into account the boundary loading and the interaction between the stiffnesses of the subregion and the rest of the structure. The approach combines the improved accuracy of the exact zooming method and the reduction in computer time inherent in the specified boundary displacement and linear constraint methods. Examples applying the method to the problem of a plate with a center hole in tensile loading are presented. D.H.

A86-37184
MODELING OF A TETHERED TWO-BODY SYSTEM IN SPACE
D. K. LE (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 86-97.

A massive tether is treated as a chain of lumped point-mass beads connected by massless flexible strings. The Lagrangian approach yields a very convenient expression for the dynamics of this system relative to a moving frame which follows the 'central' direction of the tether. For all practical simulation purposes, it is enough to approximate this expression of the system's relative dynamics to the first order. A simple and numerically stable method is then presented for simulating the interaction between the tether dynamics and the orbital motions of the connected heavy bodies. Author

A86-37861#
LARGE SPACE STRUCTURAL MODELS BY COMBINATION OF FINITE ELEMENTS AND TRANSFER MATRIX METHODS [MODELLI STRUTTURALI DI GRANDI STRUTTURE-SPAZIALI PER COMBINAZIONE DEI METODI AGLI ELEMENTI FINITI E DELLA MATRICE DI TRANSFERIMENTO]
L. LECCE, F. MARULO, and G. BUONO (Napoli, Universita, Naples, Italy) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 153-161. In Italian. refs

To implement a structural model able to study large space structures, a methodology is proposed based on a proper combination of the finite Element and Transfer Matrix Methods. Taking into account the repetitive aspect of such structures, it is possible to gain full advantage of the Transfer Matrix Method applied to periodic structures, without loss of the detail offered by the FEM. Some examples involving simple structures are presented, showing the characteristics and the reliability of the proposed method. Finally the implementation on already existing structural computer code (NASTRAN, SAP, etc.) is discussed and proposed to take full advantage of the method. D.H.

A86-38061
OPTIMIZING ACCURACY IN TRIANGULATION FOR GEOMETRICAL VERIFICATION OF LARGE SPACE STRUCTURES
A. M. C. HOLMES (Lockheed Missiles and Space Co., Inc., Palo Alto, CA) IN: International Instrumentation Symposium, 31st, San Diego, CA, May 6-9, 1985, Proceedings . Research Triangle Park, NC, Instrumentation Society of America, 1985, p. 261-270.

The triangulation process used for geometrical verification of large space structures such as deployable antenna reflectors is analyzed. The selection and placement of the proper reference length considering the theodolite are examined. A computer program, ERNA, for optimizing the theodolite placement in relation to the measurement span is described. Utilizing the triangulation process with reference lengths which are 80 percent of the desired measurement spans, accuracies of + or - 0.013 in. and + or - 0.024 in. are achieved for spans of 100 and 200 ft, respectively. I.F.

A86-38813*# Massachusetts Inst. of Tech., Cambridge.
EXPERIMENTAL VERIFICATION OF DISTRIBUTED PIEZOELECTRIC ACTUATORS FOR USE IN PRECISION SPACE STRUCTURES
E. F. CRAWLEY and J. DE LUIS (MIT, Cambridge, MA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 116-124. refs
(Contract NAGW-21)
(AIAA PAPER 86-0878)

An analytic model for structures with distributed piezoelectric actuators is experimentally verified for the cases of both surface-bonded and embedded actuators. A technique for the selection of such piezoelectric actuators' location has been developed, and is noted to indicate that segmented actuators are always more effective than continuous ones, since the output of each can be individually controlled. Manufacturing techniques for the bonding or embedding of segmented piezoelectric actuators are also developed which allow independent electrical contact to be made with each actuator. Static tests have been conducted to determine how the elastic properties of the composite are affected by the presence of an embedded actuator, for the case of glass/epoxy laminates. O.C.

A86-38845#
OPTIMUM DESIGN OF LARGE STRUCTURES WITH MULTIPLE CONSTRAINTS
R. A. CANFIELD, V. B. VENKAYYA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and R. V. GRANDHI (Wright State University, Dayton, OH) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 398-408. USAF-supported research. refs
(AIAA PAPER 86-0952)

Relative numerical efficiencies of different commonly used optimization techniques for solving problems with multiple constraints have been compared with an aim of developing an efficient optimization method for the automated design of large aerospace structures. A hybrid algorithm using both optimality criteria and mathematical programming methods is suggested. As a result of the study, the CONMIN computer program, and possibly NEWSUIT-A, will be used in conjunction with an optimality criteria algorithm built from OPTSTAT to develop the multidisciplinary hybrid optimization algorithm. I.S.

A86-38847*# Structural Dynamics Research Corp., San Diego, Calif.
SPACE STATION MULTIDISCIPLINARY ANALYSIS CAPABILITY - IDEAS2
M. BAKER, H. D. CHIGER, J. A. HABERMEYER, P. J. HIPOL, C. L. JOHNSON (Structural Dynamics Research Corp., San Diego, CA), and L. J. DERYDER (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 421-434.
(AIAA PAPER 86-0954)

A computer-aided engineering tool now in use at NASA for systems engineering and integration analysis of the Space Station is described. This tool, called IDEAS2, combines the spacecraft-specific analysis software from NASA IDEAS (truss synthesizer, rigid body controls, plume impingement, orbital lifetime, orbit heat loads, and life support systems) with the interactive graphics, geometric database, solids modeler, structural and thermal analysis capability of the SDRC I-DEAS to obtain an integrated package suitable for Space Station design. This integrated package was applied to a very recent study of growth scenarios of the Space Station dual keel configuration, in which a comparison was made between designs using a combination of photovoltaic solar arrays and solar dynamic collectors, and those using only solar dynamic collectors. Author

A86-38953*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
AN IMPROVED MULTILEVEL OPTIMIZATION APPROACH FOR THE DESIGN OF COMPLEX ENGINEERING SYSTEMS
J.-F. M. BARTHELEMY (Virginia Polytechnic Institute and State University, Blacksburg) and M. F. RILEY (PRC Kentron, Inc., Hampton, VA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics, and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986. 15 p. refs
(Contract NAG1-145)
(AIAA PAPER 86-0950)

Multilevel optimization methods are being considered for the design of complex systems on distributed networks of computers or even parallel processors. An obstacle to the use of multilevel methods is that they can be computationally expensive because of the cycling necessary to account for the coupling between the subproblems. This research effort aims at increasing the efficiency of multilevel optimization by adapting two techniques that are widely used in conventional one-level optimization: constraint approximation and temporary constraint deletion. These improvements are implemented and tested on three-, ten- and 52-bar planar truss designs. The results show that for larger problems (approximately 100 design variables and larger), the cost of analysis dominates the total cost so that multilevel optimization is no more expensive than one-level optimization. If parallel processing is used or the analysis process itself is decomposed, then multilevel optimization stands to become more economical than one-level optimization. Author

A86-39490#
REDUCED ORDER MODELS FOR DISTRIBUTED SYSTEMS BASED ON HANKEL-NORM APPROXIMATIONS
R. F. CURTAIN (Groningen, Rijksuniversiteit, Netherlands), K. GLOVER, and J. LAM (Cambridge University, England) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 231-244. refs

Recently the authors have developed a mathematical theory for finite-dimensional approximations for a class of infinite-dimensional systems based on its Hankel operator. The feasibility of this approach is investigated by considering two examples which model some of the essential features of large flexible structures. Author

A86-39888#
DEVELOPMENT OF A GENERALIZED RADIATOR WEIGHT OPTIMIZATION DESIGN CODE FOR HIGH POWER SPACECRAFT APPLICATIONS
S. J. MERTESDORF (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p. refs
(AIAA PAPER 86-1268)

A heat pipe radiator weight optimization computer code is under development for high power spacecraft applications. The code can be used for preliminary design or for the assessment of radiator components. It is assumed that heat is supplied to the radiator by a constant temperature two-phase thermal bus. Included in the radiator weight are the heat pipe, radiating fin, and the thermal bus/radiator heat exchanger. The code minimizes the radiator weight with respect to both the heat pipe spacing and heat exchanger temperature drop. The fin efficiency may be chosen by the user or the code can optimize with respect to this parameter. Preliminary results indicate large weight penalties when utilizing high capacity heat pipes or contact heat exchangers. Additionally, a significant radiator weight reduction could be achieved by increasing the ratio of the fin thermal conductivity to density. Additional work is required to assess the weight penalty associated with the structural and micrometeoroid survivability requirements. Author

A86-39924#
CONCEPTUAL DESIGN OF AN 1 M LONG 'ROLL OUT FIN' TYPE EXPANDABLE SPACE RADIATOR
R. PONNAPPAN (Universal Energy Systems, Inc., Dayton, OH), J. E. BEAM, and E. T. MAHEFKEY (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p. USAF-sponsored research. refs
(AIAA PAPER 86-1323)

Waste heat rejection in space at temperatures 300-423 K is posing technological problems for spacecraft of 100 KW capacity or more. The development of a light weight expandable type radiator is the prime objective of this work. A vapor pressure activated, expandable, near-room temperature, roll out type radiator fin working on phase change of fluid (evaporation and condensation) has been developed. The demonstration testing of a 1 m long 10 cm wide fin segment of the radiator is explained. A mass to radiating power ratio of the order of 1 Kg/KW is possible and large radiator panels can be constructed using modular concept. Author

A86-40521
EVA SUIT GLOVE DESIGN
B. PEACOCK, R. SHAMBAUGH, F. STRITZ (Oklahoma, University, Norman), and J. HORDINSKY (FAA, Oklahoma City, OK) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 8-14 to 8-25. refs

Traditional testing of gloves has been a subjective study by experienced designers and astronauts. An objective series of standardized tests were developed to test dexterity, strength, and tactility in a single-handed vacuum chamber. A finite element analysis simulates the effects of restraints and pleats at various glove pressures. For the finger, the incorporation of a lateral restraint and pleats on both the front and back of the joint led to near zero resistance to bending. A total glove model also was developed. A process was developed which used a computer to control the movement of an air jet to lay down continuous fiber on a fine mesh which overlaid a suction mechanism. With this technique, gloves can be quickly and economically produced with infinite selectibility of size, construction, and materials. Author

A86-40613*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTEGRATED ANALYSIS TOOLS FOR TRADE STUDIES OF SPACECRAFT CONTROLLER AND SENSOR LOCATIONS
L. F. ROWELL (NASA, Langley Research Center, Hampton, VA) AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 14 p. refs
(AIAA PAPER 86-1192)

The present investigation was conducted with the aim to evaluate the practicality and difficulties of modern control design methods for large space structure controls. The evaluation is used as a basis for the identification of useful computer-based analysis tools which would provide insight into control characteristics of a spacecraft concept. A description is presented of the wrap-rib antenna and its packaging concept. Attention is given to active control requirements, a mathematical model of structural dynamics, aspects of sensor and actuator location, the analysis approach, controllability, observability, the concept of balanced realization, transmission zeros, singular value plots, analysis results, model reduction, and an interactive computer program. It is pointed out that the application of selected control analysis tools to the wrap-rib antenna demonstrates several capabilities which can be useful during conceptual design. G.R.

A86-43216
ELECTRONIC COMPENSATION FOR STRUCTURAL DEFORMATIONS OF LARGE SPACE ANTENNAS
R. X. MEYER (Aerospace Corp., Los Angeles, CA) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 277-285.
(AAS PAPER 85-395)

A conceptual design for large, spaceborne, phased-array antennas is considered. The principal feature of the control system is a purely electronic compensation for structural deformations of the antenna. A planar array, corporate fed, with a perpendicular mast is considered. Each phased-array element receives calibration RF signals from two sources located on the mast. The analysis shows the perhaps surprising result that even though the mast is also allowed to arbitrarily deflect, all structural deflections can be correctly compensated for to first order by relating the array phase shifter inputs to phase differences in the calibration signals. The algorithm for the control loop is described. Author

A86-43223* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MODELING, ESTIMATION AND IDENTIFICATION METHODS FOR STATIC SHAPE DETERMINATION OF FLEXIBLE STRUCTURES
G. RODRIGUEZ and R. E. SCHEID, JR. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 409-429. refs
(AAS PAPER 85-424)

This paper outlines methods for modeling, identification and estimation for static determination of flexible structures. The shape estimation schemes are based on structural models specified by (possibly interconnected) elliptic partial differential equations. The identification techniques provide approximate knowledge of parameters in elliptic systems. The techniques are based on the method of maximum-likelihood that finds parameter values such that the likelihood functional associated with the system model is maximized. The estimation methods are obtained by means of a function-space approach that seeks to obtain the conditional mean of the state given the data and a white noise characterization of model errors. The solutions are obtained in a batch-processing mode in which all the data is processed simultaneously. After methods for computing the optimal estimates are developed, an analysis of the second-order statistics of the estimates and of the related estimation error is conducted. In addition to outlining the above theoretical results, the paper presents typical flexible

structure simulations illustrating performance of the shape determination methods. Author

A86-43756
NONLINEAR DEFORMATION ANALYSIS OF THE OLYMPUS ASTROMAST [NICHTLINEARE VERFORMUNGSANALYSE DES OLYMPUS ASTROMAST]
O. BRUNNER (IKO Software Service GmbH, Stuttgart, West Germany), M. EIDEN, and C. STAVRINIDIS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: International FEM-Congress, 14th, Baden-Baden, West Germany, November 18, 19, 1985, Proceedings . Stuttgart, West Germany, IKOSS GmbH, 1985, p. 145, 147-159. In German.

LARSTRAN 80, a nonlinear quasi-static updated-Lagrange finite-element program developed at the Universitaet Stuttgart (1984) to treat problems with large extensions and deflections, is applied to the extension process of the Astromast for the Olympus satellite. The Astromast is a coilable continuous-longeron GFRP structure intended to support the Olympus solar arrays, and its components are subject to large deformations, material nonlinearities, and contact forces during extension. The construction of a 10-bay FEM mast model, the nonlinear computation strategy, and the techniques used to obtain experimental measurements on a 3-m demonstration model of the mast are described, and the results are presented in tables, graphs, and drawings. The FEM technique is found to give accurate predictions of the forces, deformations, and dynamic processes encountered in the deployment sequence. T.K.

A86-46465#
INTEGRATED DESIGN OF SPACE STRUCTURES USING LATTICE PLATE FINITE ELEMENTS
S. E. LAMBERSON (U.S. Air Force Academy, Colorado Springs, CO) and T. Y. YANG (Purdue University, West Lafayette, IN) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 743-750) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 478-484. Previously cited in issue 13, p. 1856, Accession no. A85-30404. refs
(Contract AF-AFOSR-83-0204)

A86-47048#
AI APPLICATIONS FOR THE SPACE STATION PROGRAM - TECHNOLOGY, DESIGN AND INTEGRATION CHALLENGES
T. M. COOK (Martin Marietta Aerospace, Denver, CO) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 4 p. refs
(AIAA PAPER 86-2315)

Initial and growth configurations of the Space Station strongly suggest that advanced command, control and information management techniques and technologies will be required for both ground and on-board functions. Such advanced technologies are expected to significantly increase crew productivity, reduce long-term support and maintenance costs, and facilitate the transfer of such technologies to the general economy. The area of artificial intelligence offers considerable promise for achieving many of these important national and international goals. This paper addresses some of the most important issues associated with incorporating artificial intelligence into the design of the Space Station, and the integration of such technologies with more traditional automation approaches. Specificially, the following challenges are discussed: (1) technology readiness, (2) function allocation/implementation criteria, (3) knowledge transfer from man to machine (knowledge engineering), and (4) test, verification and validation methods. Author

A86-47115* Howard Univ., Washington, D. C.
INTERACTIVE COMPUTER GRAPHICS AND ITS ROLE IN CONTROL SYSTEM DESIGN OF LARGE SPACE STRUCTURES
A. S. S. R. REDDY (Howard University, Washington, DC) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 2 . Schenectady, NY, Union College, 1985, p. 782-788. Research supported by Howard University and NASA. refs

This paper attempts to show the relevance of interactive computer graphics in the design of control systems to maintain attitude and shape of large space structures to accomplish the required mission objectives. The typical phases of control system design, starting from the physical model such as modeling the dynamics, modal analysis, and control system design methodology are reviewed and the need of the interactive computer graphics is demonstrated. Typical constituent parts of large space structures such as free-free beams and free-free plates are used to demonstrate the complexity of the control system design and the effectiveness of the interactive computer graphics. Author

A86-47413*# Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.
A THREE-MASS TETHERED SYSTEM FOR MICRO-G/VARIABLE-G APPLICATIONS
E. C. LORENZINI (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 97-105. refs
(Contract NAS8-36606)
(AIAA PAPER 86-1990)

This paper describes a Space-Station attached tethered system for micro-g/variable-g applications. The system consists of three platforms: the Space Station, an end mass anchored at the end of a 10 km long kevlar tether and a micro-g/variable-g laboratory with the capability of crawling along the tether. Control strategies are devised for performing both the deployment and the station-keeping maneuvers of the system. Effective algorithms are identified for damping out the major vibrational modes. Author

A86-48713* Kansas State Univ., Manhattan.
IMPROVED FLEXIBILITY OF AN EVA GLOVE
G. W. EGGEMAN and J. J. HELD (Kansas State University of Agriculture and Applied Science, Manhattan) IN: 1986 SEM Spring Conference on Experimental Mechanics, New Orleans, LA, June 8-13, 1986, Proceedings . Bethel, CT, Society for Experimental Mechanics, Inc., 1986, p. 788-792. NASA-supported research.

A student design contest was held between four universities. The project was to improve the flexibility of the NASA extra-vehicular activities (EVA) glove with the internal pressure increased from 4 psi to 8 psi. The Kansas State University team used an experimental design methodology and an industrial management scheme. This approach succeeded in making Kansas State University the winner of the competition. Author

N86-24541*# Tennessee Technological Univ., Cookeville. Dept. of Mathematics and Computer Science.
RELIABILITY MODELS APPLICABLE TO SPACE TELESCOPE SOLAR ARRAY ASSEMBLY SYSTEM
S. A. PATIL *In* NASA. Marshall Space Flight Center Research Reports: 1985 NASA/ASEE Summer Faculty Fellowship Program 26 p Jan. 1986 refs
Avail: NTIS HC A99/MF E04 CSCL 03A

A complex system may consist of a number of subsystems with several components in series, parallel, or combination of both series and parallel. In order to predict how well the system will perform, it is necessary to know the reliabilities of the subsystems and the reliability of the whole system. The objective of the present study is to develop mathematical models of the reliability which are applicable to complex systems. The models are determined by assuming k failures out of n components in a subsystem. By taking k = 1 and k = n, these models reduce to parallel and series models; hence, the models can be specialized to parallel,

series combination systems. The models are developed by assuming the failure rates of the components as functions of time and as such, can be applied to processes with or without aging effects. The reliability models are further specialized to Space Telescope Solar Arrray (STSA) System. The STSA consists of 20 identical solar panel assemblies (SPA's). The reliabilities of the SPA's are determined by the reliabilities of solar cell strings, interconnects, and diodes. The estimates of the reliability of the system for one to five years are calculated by using the reliability estimates of solar cells and interconnects given n ESA documents. Aging effects in relation to breaks in interconnects are discussed. Author

N86-27375# Centre National d'Etudes Spatiales, Toulouse (France).
DEFINITION AND TESTING OF GEARS FOR SPACE ROBOTICS
L. PETITJEAN and A. BORRIEN *In* ESA Second European Space Mechanisms and Tribology Symposium p 149-154 Dec. 1985 In FRENCH; ENGLISH summary
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

An automatic manipulator arm for the capture of a three-axis stabilized satellite by another satellite on the same orbit was investigated. A general design study highlighted critical technological problems, such as the design and manufacturing of the joint gear-boxes, as the joints must transmit high forces and torques (60 Nm holding torque) which induce high contact stresses on the gear teeth. The research in lubrication processes, the experimental program to prove the feasibility of the concept, and the test results under atmosphere are summarized. ESA

N86-27387# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
A DORNIER LATCH DESIGN FOR A DOCKING MECHANISM
K. PRIESETT, F. GAMPE, R. H. BENTALL, and N. CABLE *In* ESA Second European Space Mechanisms and Tribology Symposium p 227-232 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Within a technology study of a spacecraft docking mechanism subsystem, it is shown that based on the selection of a very low impact docking concept, a simple latching and connecting interface can be applied to the coupling of two spacecraft. Structural joining is accomplished by three or four equispaced capture latches. A capture latch mechanism for this docking technique is described. Latching requirements, the standard docking interface, the latch mechanism design and analysis, and results of a predevelopment model latch test are outlined. ESA

N86-27403*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
COMMUNICATION PLATFORM PAYLOAD DEFINITION (CPPD) STUDY. VOLUME 1: EXECUTIVE SUMMARY Final Report, Jun. 1984 - Jul. 1985
E. M. HUNTER Mar. 1986 40 p
(Contract NAS3-24235)
(NASA-CR-174928; NAS 1.26:174928; WDL-TR-10631-VOL-1)
Avail: NTIS HC A03/MF A01 CSCL 22B

This is Volume 1 (Executive Summary) of the Ford Aerospace & Communications Corporation Final Report for the Communication Platform Payload Definition (CPPD) Study program conducted for NASA Lewis Research Center under contract No. NAS3-24235. This report presents the results of the study effort leading to five potential platform payloads to service CONUS and WARC Region 2 traffic demand as projected to the year 2008. The report addresses establishing the data bases, developing service aggregation scenarios, selecting and developing 5 payload concepts, performing detailed definition of the 5 payloads, costing them, identifying critical technology, and finally comparing the payloads with each other and also with non-aggregated equivalent services. Author

N86-27404*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
COMMUNICATION PLATFORM PAYLOAD DEFINITION (CPPD) STUDY. VOLUME 2: TECHNICAL REPORT Final Report, Jun. 1984 - Jul. 1985
E. M. HUNTER, T. DRIGGERS, and R. JORASCH Mar. 1986 598 p
(Contract NAS3-24235)
(NASA-CR-174929; NAS 1.26:174929; WDL-TR-10632-VOL-2)
Avail: NTIS HC A25/MF A01 CSCL 22B

This is Volume 2 (Technical Report) of the Ford Aerospace & Communications Corporation Final Report for the Communication Platform Payload Definition (CPPD) Study program conducted for NASA Lewis Research Center under contract No. NAS3-24235. This report presents the results of the study effort leading to five potential platform payloads to service CONUS and WARC Region 2 traffic demand as projected to the year 2008. The report addresses establishing the data bases, developing service aggregation scenarios, selecting and developing 5 payload concepts, performing detailed definition of the 5 payloads, costing them, identifying critical technology, and finally comparing the payloads with each other and also with non-aggregated equivalent services. Author

N86-27405*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
COMMUNICATION PLATFORM PAYLOAD DEFINITION (CPPD) STUDY. VOLUME 3: ADDENDUM Final Report, Jun. 1984 - Jul. 1985
E. M. HUNTER, T. DRIGGERS, and R. JORASCH Mar. 1986 424 p
(Contract NAS3-24235)
(NASA-CR-174930; NAS 1.26:174930; WDL-TR-10633-VOL-3)
Avail: NTIS HC A18/MF A01 CSCL 22B

This is Volume 3 (Addendum) of the Ford Aerospace & Communications Corporation Final Report for the Communication Platform Payload Definition (CPPD) Study Program conducted for NASA Lewis Research Center under contract No. NAS3-24235. This report presents the results of the study effort leading to five potential platform payloads to service CONUS and WARC Region 2 traffic demand as projected to the year 2008. The report addresses establishing the data bases, developing service aggregation scenarios, selecting and developing 5 payload concepts, performing detailed definition of the 5 payloads, costing them, identifying critical technology, and finally comparing the payloads with each other and also with non-aggregated equivalent services. Author

N86-28118# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France). Lab. des Materiaux.
DESIGN OF BONDED STRUCTURAL JOINTS FOR SPACECRAFT [CALCUL DES LIASONS COLLEES STRUCTURALES DANS LES VEHICULES SPATIAUX]
J. P. MAIGRET and M. MARTIN 1986 20 p In FRENCH Presented at Colloq. sur les Tendances en Calcul des Struct., Bastia, France, 6-8 Nov. 1985
(SNIAS-861-430-105; ETN-86-97167) Avail: NTIS HC A02/MF A01

It is shown that for designing bonded joints, computer programs must include joint geometry, stress, environment, tolerances, and adhesive characteristics. The results of the experimental evaluation of characterization methods are presented and the most important unsolved problems are indicated. ESA

N86-28409*# Consiglio Nazionale delle Ricerche, Rome (Italy). Programma Spaziale Nazionale.
TETHERED SATELLITE DESIGN
G. MANARINI *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 63-79Vol-1) Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

The capability of the satellite to perform a variety of space operations to be accomplished from the shuttle is reviewed

considering use of the satellite with man-in-loop and closed loop modes and deployment (toward or away from Earth, up to 100 km), stationkeeping, retrieval and control of the satellite. Scientific payloads are to be used to perform experiments and scientific investigation for applications such as magnetometry, electrodynamics, atmospheric science, chemical release, communications, plasmaphysics, dynamic environment, and power and thrust generation. The TSS-S will be reused for at least 3 missions after reconfiguration and refurbishment by changing the peculiar mission items such as thermal control, fixed boom for experiments, aerodynamic tail for yaw attitude control, external skin, experiments, and any other feature. The TSS-S is to be composed of three modules in order to allow independent integration of a single module and to facilitate the refurbishment and reconfiguration between flights. The three modules are service, auxiliary propulsion, and payload modules. E.R.

N86-30776# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
HOLOGRAPHIC INTERFEROMETRY FOR DISTORTION MEASUREMENTS OF ANTENNAS
H. U. FREY *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 149-155 Feb. 1986
Avail: NTIS HC A16/MF A01

Holographic interferometry was developed and adapted to a space environment simulation chamber. The test method is described and test results of antenna dishes from 1.2 to 3.6 m diameter are presented. ESA

N86-31418*# Prairie View Agricultural and Mechanical Coll., Tex. Dept. of Electrical Engineering.
AN IBM PC-BASED MATH MODEL FOR SPACE STATION SOLAR ARRAY SIMULATION
E. M. EMANUEL *In* NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 28 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 10A

This report discusses and documents the design, development, and verification of a microcomputer-based solar cell math model for simulating the Space Station's solar array Initial Operational Capability (IOC) reference configuration. The array model is developed utilizing a linear solar cell dc math model requiring only five input parameters: short circuit current, open circuit voltage, maximum power voltage, maximum power current, and orbit inclination. The accuracy of this model is investigated using actual solar array on orbit electrical data derived from the Solar Array Flight Experiment/Dynamic Augmentation Experiment (SAFE/DAE), conducted during the STS-41D mission. This simulator provides real-time simulated performance data during the steady state portion of the Space Station orbit (i.e., array fully exposed to sunlight). Eclipse to sunlight transients and shadowing effects are not included in the analysis, but are discussed briefly. Integrating the Solar Array Simulator (SAS) into the Power Management and Distribution (PMAD) subsystem is also discussed. Author

N86-31629 Centre National d'Etudes Spatiales, Toulouse (France).
DESIGN OF SPACECRAFT
D. MARTY and F. DALLEST 1986 669 p In FRENCH; ENGLISH summary
(ISBN-2-225-80732-9; ETN-86-97643) Avail: CEPADUES, Toulouse, France

Satellite orbit calculation, orbit perturbations, structural design, thermal control, satellite tests, interplanetary vehicles, conventional launchers, space shuttles, avionics, propulsion, stability and optimization are covered in this textbook. ESA

N86-31640# Societe Nationale Industrielle Aerospatiale, Cannes (France).
DESIGN AND TEST OF A SPACE DEPLOYABLE RADIATOR
B. MOSCHETTI, M. AMIDIEU, and B. TATRY 1986 8 p
(SNIAS-861-440-103; ETN-86-97612) Avail: NTIS HC A02/MF A01

A deployable panel of hinged type where the power is spread over the surface by means of embedded heat pipes and the thermal rotating joints are coaxial with the panel hinge is described. The prototype model has a radiation panel of 800 x 600 mm with 5 embedded heat pipes and 2 radiative faces capability. In the hot case the capability is 160 W to maintain 30 C. Thermal performance test results are given. ESA

03

STRUCTURAL CONCEPTS

Includes erectable structures (joints, struts, and columns), deployable platforms and booms, solar sail, deployable reflectors, space fabrication techniques, and protrusion processing.

A86-33287
SPACECRAFT STRUCTURES DESIGN AND VERIFICATION
C. STAVRINIDIS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 669-671. refs

The scope and associated cost related with spacecraft structures design and verification depend on such factors as the weight criticality, and the degree of dynamic interaction of the payload with the launch vehicle. For large complex spacecraft which often have significant dynamic interaction with a launch vehicle, structural design and verification usually require a combination of analysis, development testing, and qualification testing. It is important when a project is initiated that the payload developer understands fully the various options, which often include specific requirements for a chosen launcher, since the selection of any of these options have a significant impact on the project cost and schedule. Author

A86-33921
INFLATABLE, SPACE-RIGIDIZED REFLECTORS FOR MOBILE MISSIONS
M. C. BERNASCONI (Contraves AG, Zurich, Switzerland), E. PAGANA (Centro Studi e Laboratori Telecomunicazioni S.p.A., Turin, Italy), and G. REIBALDI (ESA, European Space Research and Technology Center, Noordwijk, Netherlands) IN: GLOBECOM '85 - Global Telecommunications Conference, New Orleans, LA, December 2-5, 1985, Conference Record. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 407-411. refs

The structural concept of a 12-m inflatable, space-rigidized antenna reflector for operations at 800-900 MHz mobile-user satellite communications is described. The method consists in inflating prepreg balloons and having them chemically rigidized in space. The reflector takes the shape of a disk whose main surfaces exhibit a slight curvature with a quasi-elliptical contour. The results on the theoretical analysis of a reflector model and the preliminary test results on a 3-m diameter rigidized prototype reflector are presented. The electrical test results, the specifications, and the performances of the nominal paraboloid are of a promising quality. I.S.

A86-34634* Howard Univ., Washington, D. C.
AN EVALUATION OF FOLDABLE ELASTIC TUBES FOR APPLICATION IN SPACE STRUCTURES
I. W. JONES (Howard University, Washington, DC), C. BOATENG (Exxon Co., Houston, TX), and C. D. WILLIAMS (Shell Oil Co., Houston, TX) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 590-598. refs
(Contract NSG-1320)

An experimental investigation and design study has been performed on one type of foldable elastic tube in order to assess its suitability as a member of deployable space structures. It is demonstrated that one or more slots inserted longitudinally in the center of the tube to alleviate strain serves to prevent collapse of the tube. The nonlinear spring characteristics of the tube that are required for computer-based deployment dynamic analysis of space structures are determined, and it is shown that strain energy levels over a certain range are realizable for tubes representing space structure members in the 15-20 ft length range. Approximate strain energy/geometric parameter relationships are developed which may be useful for preliminary design or concept studies. C.D.

A86-34987
TRUSS STRUCTURE ADVANCED DEVELOPMENT FOR SPACE STATION
J. F. DUBEL (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 12-7 to 12-11.

This paper identifies three challenging structural aspects to the Space Station program. The first is to define the relationship between the structure and the attitude control system. The second is to determine the truss structure material that meets current initial operating capability and growth requirements. The third is to determine how much truss structure deployment will be automatic and how much will require crew interface operations. This mix of automatic and crew operations involves rigidizing joints, articulating utility lines and supports, packaging, accommondating requirements imposed by extravehiculer activites (EVA), preparing for growth, and other automatic and crew interface provisions. Author

A86-35215* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPTIMIZATION OF MASS PLACEMENT IN SPACE STATION APPLICATIONS
M. J. FEREBEE, JR. (NASA, Langley Research Center, Hampton, VA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 17 p.
(SAWE PAPER 1672)

A methodology is presented by means of which the projected NASA Space Station's structural elements, primarily involving externally attached masses reresenting payloads, can be prearranged to meet all constraints imposed on Station design by mission type, safety, and physical criteria. Five different configurations are considered. The methodology has been automated in the form of a computer-aided engineering tool for the optimization of masses with respect to the products of inertia. By minimizing the induced gravity-gradient torques, the momentum buildup over an orbital period is also minimized. O.C.

A86-36029#
ESA-SPONSORED DEVELOPMENTS IN THE FIELD OF DEPLOYABLE MASTS
M. A. AGUIRRE-MARTINEZ (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 9, no. 3, 1985, p. 313-321.

The agency is sponsoring two parallel development efforts in the field of advanced deployable masts. Both are extending tube devices capable of pushing out solar arrays and deploying such items as antennas and scientific experiments. This paper describes their current status and the present and future applications for such devices. It includes a presentation of the background to the two programmes, functional descriptions of the devices, and analyses of their performances. Author

A86-38809*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VERIFICATION OF LARGE BEAM-TYPE SPACE STRUCTURES
C.-F. SHIH, J. C. CHEN, and J. A. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 78-84. NASA-supported research. refs
(AIAA PAPER 86-0860)

The verification approach here proposed for large, beam-type space structures consists of a first part, which removes the gravity effect on the substructure tested and identifies its on-orbit dynamic characteristics, on the basis of ground test measurements, and a second part which develops an adequate scaling law that extrapolates the dynamic characteristics of the prototype structure by using results from the substructure. These approaches are presently demonstrated for the cases of a wrap-rib antenna's feed support structure and a candidate Space Shuttle flight experiment. O.C.

A86-38854#
BUCKLING AND NON-LINEAR RESPONSE OF IMPERFECT THREE-LEGGED TRUSS COLUMNS
D. ELYADA (Raphael Armament Development Authority, Haifa, Israel) and C. D. BABCOCK (California Institute of Technology, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 495-501. Research supported by the California Institute of Technology. refs
(AIAA PAPER 86-0974)

A closed form theoretical investigation of the non-linear structural behavior of idealized imperfect three-legged truss columns is presented. The columns examined have equilateral-triangular cross-sections formed by three longerons held in place by equally spaced battens. The columns are simply-supported and loaded by a pure axial compressive force. Local as well as global finite geometrical imperfections are admitted. Closed form expressions are obtained for local and global buckling, post-buckling, imperfection sensitivities, non-linear response and limit loads. Local-global mode interaction is fully accounted for. Comparisons are made with numerical results and those in the literature. Author

A86-38879#
REDUCED MODELING AND ANALYSIS OF LARGE REPETITIVE SPACE STRUCTURES VIA CONTINUUM/DISCRETE CONCEPTS
K. C. SAW and K. K. TAMMA (West Virginia University, Morgantown) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 720-729. refs
(AIAA PAPER 86-1022)

The paper describes reduced modeling/analysis approaches for repetitive lattice configurations with emphasis on tetrahedral type space structures although the basic concepts can be extended to general repetitive lattice structures as well. The approach is based on transforming the actual configuration to a significantly reduced discrete configuration using scaling transformations and constitutive properties derived via the concept of equivalent continuum. Therein, the approach seeks to model/analyze the much simpler and reduced configurations, wherein, transformations and extrapolation/interpolation procedures are utilized to relate back the response to that of the significantly complex actual configurations. The effectiveness and accuracy of the approach is demonstrated via comparisons with detailed analysis of the actual

models. Results obtained are in good agreement and the approach offers potential for further extension. Author

A86-38881#
COMPARISON OF TENSION STABILIZED STRUCTURES FOR LARGE SPACE ANTENNA REFLECTORS
J. J. HERBERT and E. E. BACHTELL (Martin Marietta Corp., Denver, CO) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 752-756.
(AIAA PAPER 86-0876)

The structural characteristics of large tension-stabilized antenna surfaces are studied. The use of tie cord systems for large space structures such as the Earth Observation Spacecraft is discussed. The design of catenary and direct tieback tie systems are examined. A nonlinear finite element technique for analyzing mesh tie systems is described; the Newton-Raphson method is utilized to solve the nonlinear stress-stiffened finite-element equation for the systems. The system designs are applied to a representative antenna configuration and compared. The effects of the thermal and gravity environment on the surface accuracy are investigated. The dynamic performance and tie cord coupling of the systems are evaluated. It is noted that both the catenary and direct tieback systems are stable designs for large space antennas; however, the direct tieback design is not cost effective to manufacture due to the extensive coupling of the system. I.F.

A86-38883*# Martin Marietta Aerospace, Denver, Colo.
HYBRID DEPLOYABLE/ERECTABLE SOLAR DYNAMIC BOX TRUSS SYSTEM
J. V. COYNER, JR. (Martin Marietta Corp., Denver, CO) and T. B. IRVINE (NASA, Lewis Research Center, Cleveland, OH) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 764-768.
(AIAA PAPER 86-0955)

The design of a hybrid deployable/erectable solar dynamic box truss power generation system for the initial operation capability (IOC) of the Space Shuttle is examined. An organic Rankine cycle heat engine for IOC solar power generation is studied. The design configuration is a simple parabolic concentration where the receiver is located in the focal plane with its aperture at the focal point. The relationship between concentrator size and collection efficiency is analyzed. The geometry of the deployable graphite/epoxy box truss ring and the reflective panels of the system are described. Mass properties and dynamic analyses are performed to evaluate the center of gravity location and moments of inertia characteristics of the energy conversion subsystem (ECS). The deployable/erectable truss is applicable for large IR space telescopes and center and offset fed ECSs. I.F.

A86-38885#
ERROR ESTIMATION AND COMPENSATION IN REDUCED DYNAMIC MODELS OF LARGE SPACE STRUCTURES
J.-S. FUH, B. GUSTAVSON, and A. BERMAN (Kaman Aerospace Corp., Bloomfield, CT) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 1-9. refs
(Contract F33615-84-C-3219)
(AIAA PAPER 86-0837)

The design of large space structures using the Guyan reduction (1965) is described. The development of linear reduced structure models to evaluate the dynamic characteristics of large space structures is discussed. The natural frequency errors that result from the Guyan reduction are examined. A minimum-ratio criterion is proposed for selecting a best set of retained degrees of freedom. The errors are reduced further using the analytical model improvement (AMI); the sensitivity of AMI under various conditions is studied. The ability of the reduced models to accurately represent the effects of structural changes is investigated. The design procedure is applied to a delta wing model and it is noted, based on the data of eigensolution and forced response computations, that the reduced models are useful for efficient structural design studies. I.F.

A86-39923#
FLUID RECIRCULATION, DEPLOYMENT AND RETRACTION OF AN EXPANDABLE PULSE POWER RADIATOR
I. C. CHOW (Kentucky, University, Lexington) and E. T. MAHEFKEY (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 7 p. USAF-sponsored research. refs
(AIAA PAPER 86-1322)

Three methods for the stowage of a space power system radiator bag are considered in the present study. Fluid recirculation, as well as the deployment and retraction of this expandable, megawatt-pulse power radiator are discussed. Attention is given to the response of the radiator to a duty cycle, the rolling in and out of the radiator bag, and alternative wiper-, liquid channel-, and rotating bag-mechanisms of condensate return. O.C.

A86-40611*# National Aeronautics and Space Administration, Washington, D.C.
FUTURE DIRECTIONS IN MATERIALS AND STRUCTURES FOR SPACE APPLICATIONS
S. L. VENNERI and R. J. HAYDUK (NASA, Washington, DC) AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 29 p. refs
(AIAA PAPER 86-1185)

A comprehensive evaluation is made of materials and structural technology requirements for future space transportation systems, large spacecraft, and space structures. Exceptional promise is noted in carbon-carbon composites for large area thermal protection systems. High temperature test facilities, techniques, and instrumentation systems have unfortunately been neglected, and a materials systems data base suitable for high confidence design of long life space structures has yet to be compiled with a view to material environments in low earth and geosynchronous orbits. A coordinated analysis, ground test, and in-orbit experimentation program for candidate structure designs is called for. O.C.

A86-41742#
PRELOAD MODELING, ANALYSIS, AND OPTIMAL DESIGN TECHNIQUES FOR BEAM/ROD/CABLE ELEMENT STRUCTURES
R. C. SHIEH (MRJ, Inc., Oakton, VA) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1, p. 299-307) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 308-315. Previously cited in issue 13, p. 1894, Accession no. A85-30261.

A86-43328#
PROSPECTS FOR INTELLIGENT AEROSPACE STRUCTURES
W. J. ROWE (Lockheed-Georgia Co., Marietta) AIAA and SOLE, Aerospace Maintenance Conference, 2nd, San Antonio, TX, May 21-23, 1986. 10 p. refs
(AIAA PAPER 86-1139)

An evaluation is made of NDE sensor and instrumentation concepts that have demonstrated promise for the future monitoring of critical structures in flight, in light of past and current efforts to implement such systems and with a view to their operational and economic advantages. Attention is given to the NDE challenges posed by advanced composite laminates, which are affected by both manufacturing and service-incurred defects. Electrical resistance strain gages in various configurations, and optical fiber-based sensors, are considered as suitable bases for composite materials' NDE systems. O.C.

A86-49818#
SIMPLIFIED LATTICE BEAM ELEMENTS FOR GEOMETRICALLY NONLINEAR STATIC, DYNAMIC, AND POSTBUCKLING ANALYSIS
D. T. BERRY and T. Y. YANG (Purdue University, West Lafayette, IN) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1, p. 316-324) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1346, 1347. Previously cited in issue 13, p. 1894, Accession no. A85-30263. refs
(Contract AF-AFOSR-83-0104)

A86-49988#
CFRP SUPPORT STRUCTURE FOR HIGH STABILITY REFLECTOR ANTENNAS
G. L. SCIALINO (Selenia Spazio S.p.A., Rome, Italy) IN: Satellite Broadcasting; Congress on Electronics, 32nd, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 169-178.

The development of support structures for a pair of 1-m-diameter steerable spot-beam antennas for spacecraft is reported. The alternative configurations and materials evaluated are indicated, and the configuration adopted, comprising two bonded tubular CFRP-laminate arms, Al-honeycomb-sandwich-plate reflector and spacecraft interfaces, and Ti launch-lock bushings, is described in detail. The analysis of thermal protection; grounding; temperature distribution; stiffness, stress, and fracture; thermal stress/distortion; and dynamic response are summarized; and some manufacturing problems are discussed. The results of tensile, sine-vibration, and thermal-cycling tests on the two complete antenna structures (weighing 8.0 and 9.2 kg) are briefly characterized. T.K.

N86-22630# Societe Nationale Industrielle Aerospatiale, Cannes (France). Div. Systemes Balistiques et Spatiaux.
ACCOMMODATION STUDY OF THE CRHESUS CRYOSTAT ON THE EURECA PLATFORM Final Report
Paris ESA May 1985 109 p refs
(Contract ESTEC-5814/84-NL-B)
(SNIAS-1048ACA/LL/V; ESA-CR(P)-2104) Avail: NTIS HC A06/MF A01

The integration and operational constraints of CRHESUS cryostat as payload on EURECA are defined. The optimum configuration for CRHESUS on EURECA is proposed. The design of the structural support, and a mechanical analysis of the whole CRHESUS plus the structural interface are provided. The data system and the electric power system between CRHESUS and EURECA, and the passive thermal control of payloads are defined. Operational constraints of the system determine ground support equipment. Studies of necessary improvements on the cryostat for compliance as EURECA payload were performed and consequences on the thermal balance and lifetime of cryostat were identified. A development plan, a schedule, and interface requirements for flight of CRHESUS on EURECA are provided.
Author (ESA)

N86-23624# Tokyo Univ. (Japan). Institute of Space and Astronautical Science.
METHOD OF PACKAGING AND DEPLOYMENT OF LARGE MEMBRANES IN SPACE
K. MIURA Dec. 1985 11 p refs
(ISAS-618; ISSN-0285-6808) Avail: NTIS HC A02/MF A01

A new concept of packaging and deployment of large membranes in space is presented. The problem of biaxially folding of a plane is transferred to the elastic problem of a biaxially compressed infinite plate. After solving the problem, the plate thickness is reduced infinitesimally small, and thus the results represents the isometric transfer of an infinite plane subject to biaxial shortening. As a result, the concave polyhedral surface is discovered, which is composed of a repetition of a fundamental region, which is further composed of four congruent parallelograms. It is shown that the packaging and deployment by this surface geometry satisfies various requirements as to operations in space. Author

N86-24652# National Aeronautics and Space Administration, Washington, D.C.
SELECTIONS FROM FLUG REVUE UND FLUGWELT INTERNATIONAL. A. ON THE BORDER OF TIME-HYPERSONIC FLIGHT. B. NASA PROGRAMS PAVE THE WAY FOR THE HYPERSONIC AIRCRAFT. C. SHUTTLE FLIGHT 61-B; CONSTRUCTION IN SPACE. D. FASTER THAN A BULLET; HYPERSONIC MILITARY AIRCRAFT
H. PENNER, K. MUELLER, H. MULLER, G. WANGE, and N. LYNN May 1986 40 p Transl. into ENGLISH of Flug Revue and Flugwelt International (West Germany), Feb. 1986 p 9-22 and 46-50 Transl. by SCITRAN, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-88418; NAS 1.15:88418) Avail: NTIS HC A03/MF A01 CSCL 01B

Planned research and future developments in hypersonic aircraft, including possible military applications of hypersonic transport aircraft are discussed. NASA's development of hypersonic aircraft is discussed. Other topics include an overview of the 61-B Space Shuttle mission that pertains to the construction of space structures. Author

N86-24729* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SHUTTLE-LAUNCH TRIANGULAR SPACE STATION Patent
W. C. SCHNEIDER, inventor (to NASA), R. B. BERKA, inventor (to NASA), C. KAVANAUGH, inventor (to NASA), K. NAGY, inventor (to NASA), R. C. PARISH, inventor (to NASA), J. A. SCHLIESING, inventor (to NASA), P. D. SMITH, inventor (to NASA), F. J. STEBBINS, inventor (to NASA), and C. J. WESSELSKI, inventor (to NASA) 1 Apr. 1986 9 p Filed 9 Mar. 1984 Sponsored by NASA
(NASA-CASE-MSC-20676-1; US-PATENT-4,579,302; US-PATENT-APPL-SN-587764; US-PATENT-CLASS-244-159)
Avail: US Patent and Trademark Office CSCL 22B

A triangular space station deployable in orbit is described. The framework is comprized of three trusses, formed of a pair of generally planar faces consistine of foldable struts. The struts expand and lock into rigid structural engagement forming a repetition of equilater triangles and nonfolding diagonal struts interconnecting the two faces. The struts are joined together by node fittings. The framework can be packaged into a size and configuration transportable by a space shuttle. When deployed, the framework provides a large work/construction area and ample planar surface area for solar panels and thermal radiators. A plurity of modules are secured to the framework and then joined by tunnels to make an interconnected modular display. Thruster units for the space station orientation and altitude maintenance are provided.
Official Gazette of the U.S. Patent and Trademark Office

N86-24867*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DEPLOYABLE GEODESIC TRUSS STRUCTURE A01 Patent Application
M. M. MIKULAS, JR., inventor (to NASA), M. D. RHODES, inventor (to NASA), and J. W. SIMONTON, inventor (to NASA) 20 Feb. 1986 15 p
(NASA-CASE-LAR-13113-1; NAS 1.71:LAR-13113-1; US-PATENT-APPL-SN-831371) Avail: NTIS HC A02/MF A01 CSCL 13B

A deployable geodesic truss structure which can be deployed from a stowed state to an erected state is described. The truss structure includes a series of bays, each bay having sets of battens connected by longitudinal cross members which give the bay its axial and torsional stiffness. The cross members are hinged at their mid point by a joint so that the cross members are foldable for deployment or collapsing. The bays are deployed and stabilized by actuator means connected between the mid point joints of the cross members. Hinged longerons may be provided to also connect the sets of battens and to collapse for stowing with the rest of the truss structure. The truss structure has the capability of serving a structural function even when only partly deployed. NASA

N86-25789* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SYNCHRONOUSLY DEPLOYABLE TRUSS STRUCTURE Patent
H. G. BUSH, inventor (to NASA), M. MIKULAS, JR., inventor (to NASA), and E. WALLSOM, inventor (to NASA) (Kentron International, Inc., Hampton, Va.) 1 Apr. 1986 8 p Filed 30 Nov. 1983 Sponsored by NASA
(NASA-CASE-LAR-13117-1; US-PATENT-4,578,920; US-PATENT-APPL-SN-556512; US-PATENT-CLASS-52-645; US-PATENT-CLASS-52-111; US-PATENT-CLASS-52-648; US-PATENT-CLASS-244-159; US-PATENT-CLASS-244-173; US-PATENT-CLASS-343-881; US-PATENT-CLASS-343-882)
Avail: US Patent and Trademark Office CSCL 13I

A collapsible-expandable truss structure, including first and second spaced surface truss layers having an attached core layer is described. The surface truss layers are composed of a plurality of linear struts arranged in multiple triangular configurations. Each linear strut is hinged at the center and hinge connected at each end to a nodular joint. A passive spring serves as the expansion force to move the folded struts from a stowed collapsed position to a deployed operative final truss configuration. A damper controls the rate of spring expansion for the synchronized deployment of the truss as the folded configuration is released for deployment by the restrain belts. The truss is synchronously extended under the control of motor driven spools.
Official Gazette of the U.S. Patent and Trademark Office

N86-27364# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
THE EXTENDABLE AND RETRACTABLE MAST (ERM)
M. SCHMID and M. AGUIRRE *In* ESA Second European Space Mechanisms and Tribology Symposium p 69-74 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The Extendable and Retractable Mast (ERM) used to deploy and retract large foldable structures such as solar arrays and furlable spacecraft antennas is presented. The design is based on a telescopic carbon-fiber structure with high stiffness, strength, and pointing accuracy. To verify the chosen design a breadboard model of an ERM was built and tested under TV conditions.
ESA

N86-27365# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
THE COLLAPSIBLE TUBE MAST (CTM)
M. AGUIRRE, A. BUREO, M. FUENTES, and J. RIVACOBA *In* ESA Second European Space Mechanisms and Tribology Symposium p 75-81 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

A biconvex tube mast that can be flattened and rolled around a drum into a small volume package is described. A drive system pulls the tube by the edges to deploy it, and rotates the stowing drum to retract it. The mast can be manufactured in metal or composite; in both cases a continuous manufacturing method is used, providing a mast of unlimited length. An engineering model with tubes in copper beryllium and carbon fiber reinforced epoxy and thermoplastic is planned.
ESA

N86-27368# Sener, S.A., Madrid (Spain).
THE ULYSSES MECHANISMS
F. ABARRATEGUI, M. FUENTES, S. UGALDEA, and M. AGUIRRE *In* ESA Second European Space Mechanisms and Tribology Symposium p 95-104 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The Ulysses (ex ISPM) radial boom, two wire booms, and a rigid axial boom are described. The radial boom is used to deploy five experiment sensors away from the spacecraft body. It is constructed with nonmagnetic materials, and consists of two articulated arms. The wire boom antennas when deployed form a 72 m tip-to-tip dipole for the radio and plasma wave experiment. The antenna element is a tape of 5 x 0.04 mm section in CuBe2 material. The axial boom antenna, located at the spinning axis, is used as a monopole antenna by the radio and plasma wave experiment. The antenna consists of a tube of lenticular section. The section shape permits the tube to be pressed flat and rolled into a drum.
ESA

N86-27389# Royal Netherlands Aircraft Factories Fokker, Amsterdam. Space Div.
A DEPLOYABLE AND RETRACTABLE STRONGBACK STRUCTURE
R. ZWANENBURG *In* ESA Second European Space Mechanisms and Tribology Symposium p 239-245 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

A deployable/retractable structure whose parts deploy or retract simultaneously was developed for spacecraft antennas, solar arrays, heat rejection systems, sensors, concentrators, and platforms. Its advantages include simplicity and high reliability; excellent strength and stiffness in deployed condition; high design flexibility without the need for complete redesign; low production cost due to large number of identical elements; low development effort; and simple ground testing.
ESA

N86-27392# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
THE OLYMPUS ANTENNA DEPLOYMENT SUBSYSTEM DESIGN AND TESTING
M. D. DEATH *In* ESA Second European Space Mechanisms and Tribology Symposium p 267-272 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Satellite Antenna Deployment Subsystem design and engineering model testing is presented. The design, test philosophies, and their implications for the hardware are discussed. Functional, vibration and thermal vacuum test results are summarized and the hardware implications considered. The consequences of the engineering model test program and its implications for qualification and flight model testing are treated.
ESA

N86-30206*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FEASIBILITY STUDY OF A DISCRETE BEARING/ROLLER DRIVE ROTARY JOINT FOR THE SPACE STATION
S. H. LOEWENTHAL and F. T. SCHULLER Jul. 1986 43 p
(NASA-TM-88800; E-3138; NAS 1.15:88800) Avail: NTIS HC A03/MF A01 CSCL 13I

The most critical mechanism on board the proposed space station is the continously rotating joint which must accurately align the solar power units with the sun during earth orbit. The feasibility of a multiple, discrete bearing supported joint driven by a self-loading, pinch drive actuator was investigated for this application. This concept appears to offer greater protection against catastrophic jamming, less sensitivity to adverse thermal gradients, greater accessibility to inorbit servicing or replacement and greater adaptability to very large (5 m) truss members than to more conventional continuous support bearing/gear reducer joints. Analytical trade studies performed herein establish that a discrete cam roller bearing support system having eight hangers around a continuous ring would provide sufficient radial and bending stiffness to prevent any degradation in the fundamental frequencies of the solar wing structure. Furthermore, it appears that the pinch roller drive mechanism can be readily sized to meet or exceed system performance and service life requirements. Wear life estimates based on experimental data for a steel roller coated with an advanced polyimide film show a continuous service life more than two orders of magnitude greater than required for this application.
Author

N86-30685# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SPACECRAFT STRUCTURES DESIGN AND VERIFICATION
C. STAVRINIDIS *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 669-671 1985
Avail: NTIS HC A99/MF E03

Definition of spacecraft design loads, design and development of spacecraft structures, and qualification and acceptance of spacecraft structures are discussed. State of the art structural engineering; maturity of methodologies; sequence of events as they arise in spacecraft projects; trends; and future requirements are described. ESA

N86-30686# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
LOW FREQUENCY DESIGN VERIFICATION OF LARGE SPACECRAFT STRUCTURES
E. ERBEN and K. ECKHARDT *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 672-682 1985 Sponsored by INTELSAT and ESTEC
Avail: NTIS HC A99/MF E03

Multiaxis vibration system (MAVIS) testing of large spacecraft structures is described. Specified acceleration time histories are compared with the realized time histories measured at base point of test item. For the uniaxial excitation compliance is very good. During two axis excitation the differences between specified and measured input time histories are significant. The deviations are associated with strong frequency and amplitude changes in the transient motion. However, these results are achieved with an open loop control configuration of test facility and improvements are possible. Simulations of antenna reactions suggest deviations between applied and specified forces but resulting acceleration responses on different structure points are comparable with results achieved in test with complete S/C (same order of maximum acceleration peaks). ESA

N86-30765# Imperial Coll. of Science and Technology, London (England). Center for Composite Materials.
THE STRENGTH OF BOLTED JOINTS IN KEVLAR RP
J. M. HODGKINSON, D. L. DEBEER, and F. L. MATTHEWS *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 53-61 Feb. 1986 Sponsored by ESA
Avail: NTIS HC A16/MF A01

Failure data for single and multibolt joints in woven Kevlar reinforced epoxy resin are presented. The results are relevant to 6-ply, 0.5 mm thick, symmetrical laminates of different fiber orientation. Bolts used were M4 diameter (d) with standard washers. Lay-up, bolt tensile load, and hence washer pressure, end (e) and width (w) effects were explored in single and double lap joint configurations. Quasi-isotropic lay-ups fail at higher stresses than orthotropic laminates, and, for sufficiently large e/d and w/d ratios, failure is in bearing with no observable edge effects. Multiple bolt tests concerned lines and rows of bolts, the pitch being varied to determine the effects of bolt interaction. These tests were performed on the preferred quasi-isotropic lay-up. ESA

N86-30769# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost.
HAND CALCULATION METHOD FOR BUCKLING OF COMPOSITE SHELL STRUCTURES
R. F. P. VANZELST *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 87-93 Feb. 1986
Avail: NTIS HC A16/MF A01

The buckling load of a simply supported composite shell structure is determined. The laminate properties including the transverse shear properties are derived from the classical laminate theory. From the general buckling equation the panel buckling allowable and the local buckling allowable of several types of cross sections are derived. The equations are put into a small FORTRAN program. Results for an undisturbed shell structure are in good agreement with the results from the finite difference program BOSOR 4. ESA

N86-30772# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
DESIGN AND MANUFACTURING ASPECTS OF SPACE TRUSSES
H. W. BERGMANN *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 109-115 Feb. 1986
Avail: NTIS HC A16/MF A01

The dimensional stability of fiber reinforced composites for large space structure trusses is discussed. Temperature and moisture effects cannot be accurately assessed by extrapolation from the response of small test coupons. The buckling strength of hollow filament-wound struts depends very sensitively on the angular directions of the individual plies. Optimal configurations can be derived by a computerized program. An alternative approach to filament-wound strut construction by surrounding a prefabricated foam core by carbon fiber rovings or fabrics is viable. The interconnection of struts in rigid three-dimensional trusses is possible by filament-wound joints with the advantages of low cost, low weight, and improved thermal compatibility. ESA

N86-30773# Construcciones Aeronauticas S.A., Madrid (Spain). Space and Systems Div.
HIGH-STABILITY TELESCOPE STRUCTURES
G. GALIPIENSO and S. DELLAMICO *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 119-132 Feb. 1986
Avail: NTIS HC A16/MF A01

A methodology for the design of structures requiring a high degree of dimensional stability, of the Space Telescope/GRIST type, was derived. The optimum structural configuration and the optimum laminate lay-up compatible with the structural strength and stiffness requirements were determined. The global behavior of the complete structure as a function of less-than-ideal component properties was established. Levels of maximum allowable deviations for real properties of components belonging to different families were determined. A method for adjustment of the coefficient of thermal expansion after manufacturing to compensate for unavoidable deviations in component properties was devised. A test method allowing measurement of very small distortions was developed. ESA

N86-30790# British Aerospace Dynamics Group, Bristol (England). Space and Communications Div.
DESIGN AND DEVELOPMENT TESTING OF THE BONDED JOINT BETWEEN A TYPICAL LAUNCH VEHICLE ATTACHMENT RING AND CFRP THRUST CONE
J. T. SHARKEY, G. H. F. NAYLER, and J. REYNOLDS *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 275-284 Feb. 1986
Avail: NTIS HC A16/MF A01

The development of the principal structural joint of a Shuttle payload is described. The joint is subjected to large tension and compression loads due to the spacecraft being cantilevered perpendicular to the direction of flight of the launch vehicle. Finite element modeling was included in the investigation of joint designs. A bonded and bolted double lap shear configuration was chosen. Manufacturing and inspection methods were developed and testing of joint samples was undertaken including static, thermal and fatigue loading. The static test results were used to determine the design allowable strength of the joint. ESA

N86-30791# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
ON THE DEVELOPMENT OF A CORRUGATED CFRP CENTRAL CYLINDER FOR SATELLITES
D. BROSDA *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 285-290 Feb. 1986
Avail: NTIS HC A16/MF A01

Development of a corrugated central cylinder for satellites in the DFS-class, including design, analyses, manufacture, assembly and tests is summarized. The central cylinder has a mean diameter of 938 mm and a length of 1780 mm. The cylinder wall consists

of a corrugated CFRP shell of variable thickness. Three CFRP rings provide for the attachment of antenna, equipment, and payload platforms. The thrust cylinder is designed to meet the standard frequency requirements (less than 15 Hz lateral and less than 35 Hz axial) and carry the loads associated with a typical satellite mass of 1400 kg whose CG position lies 1000 mm above the separation plane. The first flight structure to be equipped with the cylinder is the German communication satellite DFS Kopernikus. ESA

N86-30792# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France).
COMPARISON OF CLASSICAL AND COCURING MANUFACTURING TECHNIQUES FOR A CFRP HONEYCOMB CENTRAL TUBE
J. L. PETTEX *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 291-294 Feb. 1986
Avail: NTIS HC A16/MF A01

Classical and cocuring manufacturing of a sandwich structure using CFRP skins and an aluminum alloy honeycomb core for the Arabsat central tube are compared. The cocuring technology leads to a simplification of the manufacturing and consequently to a cost reduction. ESA

N86-30797# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
DEVELOPMENT OF AN ANTENNA STRUCTURE FOR A DEPLOYABLE OFFSET ANTENNA
H. HERBIG, W. TAUBER, and H. VORBRUGG *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 329-336 Feb. 1986
(Contract ESTEC-5206/82-NL-PB(S6))
Avail: NTIS HC A16/MF A01

An unfurlable spacecraft antenna is described. The antenna consists of a central hub, ribs being radially arranged around the hub, and a mesh which produces the parabolic reflector surface shape. The hub and the ribs are made of CFRP. For the stowed and deployed reflector configuration the CFRP-components were analyzed and optimized under dynamical and dimensional stability aspects. The analytical results and the development of the CFRP components are presented. ESA

N86-31606*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
EVALUATION OF SOLAR ARRAY FLIGHT EXPERIMENT RESPONSE DURING FLIGHT FOR EXTENSION/RETRACTION PHASE
J. SLABY Jun. 1986 17 p
(NASA-TM-86551; NAS 1.15:86551) Avail: NTIS HC A02/MF A01 CSCL 22A

This post flight evaluation of the Solar Array Flight Experiment's (SAFE) deployment dynamics explains the encountered resonances. Author

N86-31630*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRELOADED SPACE STRUCTURAL COUPLING JOINTS Patent Application
M. D. RHODES, inventor (to NASA) 30 Jul. 1986 16 p
(NASA-CASE-LAR-13489-1; US-PATENT-APPL-SN-890445; NAS 1.71:LAR-13489-1) Avail: NTIS HC A02/MF A01 CSCL 22B

This invention relates to a coupling device for tubular members, of large truss structures, with a locking collar being the only moving part. Each tubular member is constructed with an end bell section that has a belled flange with a mating face, and a necked area which is smaller in diameter than the tubular members to be joined. A split ring is affixed to each tubular member and is constructed so that when two tubular members are laterally moved into axial alignment and the collar is rotated thereover, the split ring loads the joint with axial force by pressing the belled flange mating surfaces together, and a preloading force is provided by the collar mating with a taper on the outside of the split rings. All free play is thereby removed by preloaded force. A major object of the invention is to provide an ability to remove and replace individual tubular members without disturbing other structural parts of a truss structure. An additional anticipated use of this joint is to couple high pressure fluid lines. NASA

N86-32622# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Space Div.
OFFSET UNFURLABLE ANTENNA, PHASE 1 Final Report
Paris ESA Mar. 1984 570 p Prepared in cooperation with TICRA Engineering Consultants
(Contract ESTEC-5206/82-NL-PB(SC))
(MBB-RX11; ESA-CR(P)-2180; ETN-86-97782) Avail: NTIS HC A24/MF A01

The configuration, technology requirements, development aspects, and experimental activities for satellite reflectors for fixed and mobile communications and television broadcasting are outlined. A 4.5 m antenna for 4 GHz, and an 8 m antenna for 1.6 GHz were studied, assuming an L-Sat type satellite. A radial rib concept with auxiliary adjustment ribs, and a three dimensional scissors concept (spatial framework) with mesh adjustment elements were compared concerning mass, stowage, volume, development risk, and reliability. For antennas of diameter from 3.6 to 12 m (12 GHz to 800 MHz) the radial rib reflector is preferred. Main advantages (with rib folding for larger reflector diameters) are: lower costs; less critical technology problems; lower development risks; high deployment reliability; lightweight intermediate ribs can adapt surface accuracy to higher frequency requirements (high application flexibility); and folded main ribs provide high package capability at larger diameters. The scissors concept is advantageous for applications requiring reflectors from 12 m diameter onwards. ESA

N86-32737* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DEPLOYABLE M-BRACED TRUSS STRUCTURE Patent
M. M. MIKULAS, JR., inventor (to NASA) and M. D. RHODES, inventor (to NASA) 12 Aug. 1986 8 p Filed 30 Jul. 1985 Supersedes N86-20799 (24 - 11, p 1783)
(NASA-CASE-LAR-13081-1; US-PATENT-4,604,844; US-PATENT-APPL-SN-760378; US-PATENT-CLASS-52-632; US-PATENT-CLASS-52-111; US-PATENT-CLASS-52-645; US-PATENT-CLASS-52-646) Avail: US Patent and Trademark Office CSCL 13I

A deployable M-braced truss structure, efficiently packaged into a compact stowed position and expandable to an operative position at the use site is described. The M-braced configuration effectively separates tension compression and shear in the structure and permits efficient structural design. Both diagonals and longerons telescope from an M-braced base unit and deploy either pneumatically, mechanically by springs or cables, or by powered reciprocating mechanisms. Upon full deployment, the diagonals and longerons lock into place with a simple latch mechanism.
Official Gazette of the U.S. Patent and Trademark Office

04

STRUCTURAL AND THERMAL ANALYSIS

Includes structural analysis and design, thermal analysis and design, analysis and design techniques, and thermal control systems.

A86-32933#
NON-DESTRUCTIVE MEASUREMENT OF RESIDUAL STRESSES
J. BERLIEN, C. BOUVIER, and G. SCOTT (Martin Marietta Corp., Michoud Div., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 23 p.

Residual stresses are responsible for the formation of contour deformations, known as oil canning, in large aerospace structures. Heat treated aluminum alloy sheet material having a thin cross section is used in the construction of the External Fuel Tank. Determination of the pattern and magnitude of residual stresses could potentially aid in correcting oil can conditions. Because measurement of residual stresses requires a nondestructive method, the use of ultrasonics has been explored. Stresses have been found to be directly proportional to the ultrasonic parameter. Determination of Stress Acoustic Constants enable conversion of the measured ultrasonic parameter to stress values in KSI. Preliminary data are presented for surveys of stress measurement on External Tank component parts. Author

A86-32943#
PREDICTED TEMPERATURE FIELD IN A THERMOMECHANICALLY HEATED VISCOPLASTIC SPACE TRUSS STRUCTURE
D. H. ALLEN and W. E. HAISLER (Texas A & M University, College Station) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1, p. 773-779) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Mar.-Apr. 1986, p. 178-183. Previously cited in issue 13, p. 1897, Accession no. A85-30311. refs
(Contract F49620-83-C-0067)

A86-33942
SPACE REFLECTOR SUPPORTED BY RADIATION PRESSURE
P. L. CSONKA (Oregon, University, Eugene) and J. J. MURAY (SRI International, Menlo Park, CA) IN: GLOBECOM '85 - Global Telecommunications Conference, New Orleans, LA, December 2-5, 1985, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 939-942.

The use of radiation pressure to support a reflector is proposed. The design of the floating telecommunication mirror is described. The inertial effects caused by the rotation of the earth are studied. The torque exerted by the radiation pressure and electromagnetic radiation is applied to control mirror orientation and induce mirror rotation. The stabilization of the mirror with respect to vertical and horizontal displacement, libration, and shape distortions is examined. I.F.

A86-35186#
DEFORMATION MEASUREMENTS ON ANTENNAS UNDER SIMULATED OUTER SPACE CONDITIONS USING HOLOGRAPHIC INTERFEROMETRY [VERFORMUNGSMESSUNGEN VON ANTENNEN UNTER WELTRAUMSIMULATIONSBEDINGUNGEN MIT HOLOGRAFISCHER INTERFEROMETRIE]
H. U. FREY (Industrieanlagen-Betriebsgesellschaft mbH, Ottobrunn, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 10 p. In German.
(DGLR PAPER 85-150)

A procedure for measuring the deformation of large dish antennas under simulated space conditions with an accuracy of + or - 0.05 mm for a 4 m antenna has been developed and successfully utilized. To assist this method, which uses holographic interferometry, a half-automated procedure for evaluating the interference images has been developed. The test method, test bed, and the evaluation procedure are described, and results of conducted tests are presented. C.D.

A86-36673
SOME PROBLEMS RELATED TO THE THERMALLY INDUCED DEFORMATIONS OF LARGE SPACE STRUCTURES [NEKOTORYE VOPROSY TEMPERATURNYKH DEFORMATSII KRUPNOGABARITNYKH KOSMICHESKIKH KONSTRUKTSII]
S. K. GROMOV IN: Conversion of solar energy . Moscow, Izdatel'stvo Nauka, 1985, p. 94-99. In Russian. refs

The problem of determining the temperature fields and thermally induced deformations of large space structures consisting of rod-like elements is examined in the stationary case, i.e., for constant external heat flow and constant temperatures at all points of the structure. In particular, attention is given to the sources of external heat fluxes, consideration of radiant heat transfer and heat conduction when determining temperature distribution along a rod, thermal bending of a cylindrical structural element, and anisotropy of the thermal expansion of a rod element. V.L.

A86-37041
THERMAL DESIGN OF AEROASSISTED ORBITAL TRANSFER VEHICLES
H. F. NELSON, ED. (Missouri-Rolla, University, Rolla) New York, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Volume 96), 1985, 578 p. No individual items are abstracted in this volume.

Recent studies concerning the design of the aeroassisted orbital transfer vehicle (AOTVs) are presented. The basic equations for the flight regimes of AOTVs and numerical calculations of flowfields over AOTVs are reviewed, and trajectories of AOTVs are addressed. The thermal protection of AOTVs and phenomena occurring at the surface of an AOTV are examined. Some individual topics discussed include: relaxation algorithm for AOTV bluff body flow, performance aerodynamics of AOTVS, multiple pass trajectories for an AOTV, and AOTV aeroheating and thermal protection study, thermal response of an AOTV with a conical brake drag, design and performance analysis of a conical aerobrake OTV concept, temperature-dependent reaction rate expressions for oxygen recombination, surface-slip equations for low Reynolds number multicomponent air flow, rate chemistry problems in the flight regimes of AOTVs, and progress in noncatalytic surfaces for metallic heat shields. C.D.

A86-37107
THERMAL ENGINEERING OF SPACECRAFT COMPOSITE STRUCTURES
R. D. KARAM (Fairchild Space Co., Germantown, MD) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 100-117. refs

Standard methods in thermal engineering are extended for application to spacecraft composites. The mathematical formulation is shown to reduce to the two-dimensional case when applied to configurations commonly encountered in spacecraft design, and the controllable parameters which affect temperature and associated distortion are identified. Thermal control is discussed in terms of treatment with surface coatings, insulation, and the use of heaters and thermostats. Vacuum testing is recommended to determine conductance and long-term operation in space. The results of trade-off studies on the Fairchild Leasecraft mounting structure are presented. Author

A86-38811#
A FINITE ELEMENT MODEL FOR THE THERMOELASTIC ANALYSIS OF LARGE COMPOSITE SPACE STRUCTURES
J. D. LUTZ, D. H. ALLEN, and W. E. HAISLER (Texas A & M University, College Station) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 96-102. refs
(Contract F49620-83-C-0067)
(AIAA PAPER 86-0875)

A finite element model is outlined for an integrated thermoelastic analysis of large composite space structures. The model allows for temperature gradients within structural member cross-sections and for bending of the members themselves. Nonlinear effects, such as radiation boundary conditions and temperature-dependent material properties are also included. Once the model is outlined, a preliminary investigation into the importance of thermally-induced forces and moments is carried out. The problem chosen is that of a long, cantilevered lattice beam in a geosynchronous orbit. For the structure and loading chosen, no significant dynamic responses, such as vibration, occurred. In addition, thermally induced axial forces were the predominant type of loading. For this problem, thermally-induced moments could be neglected. The magnitude of axial stresses generated by the transitioon from shadow to sunlight is on the order of 30 percent of yield stress. Author

A86-38823*# Old Dominion Univ., Norfolk, Va.
A TAYLOR-GALERKIN FINITE ELEMENT ALGORITHM FOR TRANSIENT NONLINEAR THERMAL-STRUCTURAL ANALYSIS
E. A. THORNTON and P. DECHAUMPHAI (Old Dominion University, Norfolk, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 210-220. NASA-USAF-supported research.
(AIAA PAPER 86-0911)

A Taylor-Galerkin finite element method for solving large, nonlinear thermal-structural problems is presented. The algorithm is formulated for coupled transient and uncoupled quasistatic thermal-structural problems. Vectorizing strategies ensure computational efficiency. Two applications demonstrate the validity of the approach for analyzing transient and quasistatic thermal-structural problems. Author

A86-39903#
APPLICATION OF CAPILLARY PUMPED LOOP HEAT TRANSPORT SYSTEMS TO LARGE SPACECRAFT
D. R. CHALMERS, J. J. PUSTAY (RCA, Astro-Electronics Div., Princeton, NJ), C. B. MOY, and E. J. KROLICZEK (OAO Corp., Greenbelt, MD) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 13 p. refs
(AIAA PAPER 86-1295)

The current developmental status of capillary pumped loop (CPL) technology, and the application of two-phased CPL heat transport systems in the future Space Station Free-Flying Platform (FFP) thermal control subsystem (TCS), advanced communications satellite TCSs, and high-powered spacecraft TCSs, are considered. The CPL permits the wick structure to be isolated in the evaporator section, and provides for the concurrent flow of liquid and vapor. An ammonia-based NASA/GSFC CPL II engineering model demonstrating a 7-kW heat transport capacity over 10 m was ground tested in 1985, and a 0.5-kW capacity model has been successfully flight tested. CPL system design concepts to satisfy mission requirements, thermal/mechanical constraints, and operational needs are discussed. Future developments will focus on capillary pump design, isolator design, system evaporator design, the condensor/heat exchanger, and the reservoir. R.R.

A86-39907*# Grumman Aerospace Corp., Bethpage, N.Y.
HEAT PIPE RADIATOR TECHNOLOGY FOR SPACE POWER SYSTEMS
A. W. CARLSON, E. GUSTAFSON (Grumman Aerospace Corp., Space Systems Div., Bethpage, NY), and B. A. ERCEGOVIC (NASA, Lewis Research Center, Cleveland, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 11 p. refs
(Contract NAS3-24665)
(AIAA PAPER 86-1300)

High-reliability high-performance deployable monogroove and dual-slot heat pipe radiator systems to meet the requirements for electric power in future space missions, such as the 300-kW(e) electric powder demand projected for NASA's Space Station, are discussed. Analytical model trade studies of various configurations show the advantages of the dual-slot heat pipe radiator for high temperature applications as well as its weight reduction potential over the 50-350 F temperature range. The ammonia-aluminum monogroove heat pipe, limited to below-180 F operating temperatures, is under development, and can employ methanol-stainless steel heat pipes to achieve operating temperatures in excess of 300 F. Dual-slot heat pipe configuration proof-of-concept testing was begun in 1985. R.R.

A86-39939#
A THERMAL CONTROL DESIGN FOR THE LEASAT F-3 SALVAGE MISSION
G. J. REYNOLDS, M. CONNOR, and R. R. GARIPAY (Hughes Engineering Mechanics Laboratory, Los Angeles, CA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p.
(AIAA PAPER 86-1340)

The thermal control system designed to condition the Leasat F-3 spacecraft's solid rocket motor is described in this paper. This passive system was used on a geosynchronous satellite that had been drifting uncontrolled in a low earth orbit environment for an extended period of time. A solar absorbing, low infrared emitting surface was designed to return the solid rocket motor to the desired operating temperatures. This concept for the passive thermal control system was not part of the initial design. The system was designed for installation by the astronauts during a Space Shuttle rescue mission. A temperature telemetry system was included in the thermal system to monitor the thermal profile of the motor. Verification of the temperature data was obtained from a thermal-vacuum test in which the flight hardware and a simulation of the spacecraft motor case were used. The flight data was correlated with the thermal math model enabling prefire temperature predictions to be made. The thermal control system was proven to be successful when the motor was fired and the satellite was placed in its proper orbit. Author

A86-39941*# OAO Corp., Greenbelt, Md.
DEVELOPMENT OF AN ADVANCED TRAPEZOIDAL AXIALLY GROOVED (ATAG) HEAT PIPE
R. F. G. RICHTER, P. J. BRENNAN (OAO Corp., Greenbelt, MD), and J. G. RANKIN (NASA, Johnson Space Center, Houston, TX) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p. refs
(AIAA PAPER 86-1342)

This paper discusses the breadboard development of an Advanced Trapezoidal Axially Grooved (ATAG) heat pipe, which will satisfy space constructible radiator heat rejection requirements for large space power systems. The ATAG heat pipe development program includes a technology demonstration of Space Station heat load and temperature requirements through the design, fabrication, and testing of breadboard and preprototype units. A parametric analysis was conducted to determine trapezoidal groove geometries that could meet the transport performance goal and could be fabricated by available extrusion technology for a diameter chosen to be compatible with an existing development test unit of a cylindrical, pressure-actuated contact heat exchanger. Performance test results for the breadboard heat pipes are presented. Author

A86-40496
DESIGN PREPARATIONS FOR LARGE SPACE STRUCTURES
H. W. BERGMANN (DFVLR, Institut fuer Strukturmechanik, Brunswick, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 159-172.

The DFVLR has undertaken a program for the evaluation of fiber-resin systems applicable to composite space structures before and after realistic exposure to simulated space environments. Also under development are computer programs for the design and analysis of such space structures, and methodologies for the validation of these programs against test structures that are sufficiently large to exhibit behaviors characteristic of lattice structures in space. Attention is being given to the influence of thermal cycling, the influence of electron irradiation, and the weight optimization of tubular components. O.C.

A86-40516* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THERMAL ANALYSIS OF THE ACCESS SPACE TRUSS
R. A. FOSS and O. H. BRADLEY (NASA, Langley Research Center, Hampton, VA) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 7-1 to 7-10. refs

This paper introduces the Assembly Concept for the Construction of Erectable Space Structure (ACCESS) experiment and describes the thermal requirements in detail. The experiment, an erectable truss beam to be flown and assembled aboard the Space Shuttle, was thermally modeled using the TRASYS and SINDA computer codes. Results from the thermal analysis are presented. Development tests dictate the application of a metallized film insulation on the aluminum beam struts to control transient orbital temperature extremes. Author

A86-42809#
ANALYSIS AND MODELING OF FLUID TRANSFER IN ORBIT
J. P. GILLE (Martin Marietta Corp., Denver, CO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1718)

The need for future systems to resupply fluids to vehicles in orbit is clearly defined. Transfer of liquid between tanks is not straight-forward because of the low-g environment. The normal procedure of venting a tank as it is filled is not applicable because of the uncertainty of liquid and gas location. A good alternative is to perform a no-vent transfer. This operation will be more difficult for cryogenic liquids, and the transfer rate is difficult to predict because of a lack of basic information on low-g processes. Two approaches are investigated. The first uses the kinetic transfer energy to promote random mixing within the receiver tank to achieve required heat transfer. The second relies on centrifugal positioning and a fine spray of liquid to achieve the same purpose. The latter approach appears to offer the advantage of being less dependent on low-g mechanisms, and is not restricted by tank size. Author

A86-47924*# Howard Univ., Washington, D. C.
THE DEVELOPMENT OF AN ENVIRONMENTAL DISTURBANCE MODEL FOR LARGE SPACE STRUCTURES AFTER THE ONSET OF THERMAL SHOCK
N. HAMSATH, P. M. BAINUM (Howard University, Washington, DC), and R. KRISHNA (Advanced Technology and Research, Inc., Burtonsville, MD) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 243-249. Research supported by the Howard University and NASA. refs
(AIAA PAPER 86-2123)

Expressions for the temperature response across a thin large space structure during and immediately following the onset of thermal shock are obtained as a function of the properties of the material and the solar incidence angle. The thermal gradients induced due to solar radiation heating result in thermal deformation. From the temperature gradient information, expressions are developed for the time history of the thermally induced deflections based on the thermoelastic relationships. The effect of the variation of the solar incidence angle and the variation of the emissivity of the surface is considered. From the deflection time history, a model of the disturbance moments is developed and evaluated for different solar incidence angles. Author

A86-49599*# Washington Univ., Seattle.
SPECULAR AND DIRECT RADIATIVE LOADS ON SPACE STRUCTURE
A. F. EMERY, A. ABROUS (Washington, University, Seattle), and D. R. HEDGLEY, JR. (NASA, Flight Research Center, Edwards, CA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p.
(Contract NAG1-41)
(AIAA PAPER 86-1355)

The use of special models for trusses, and of fast graphical computational techniques, are discussed to reduce the computation times of intersurface radiation loads and specularly reflected radiation. The conditions under which the One-Dimensional approximation can be used, and the computation of the obstructed view factors for arbitrary surfaces, including the One-Dimensional surface, are considered using both contour and double area integration. The Adaptive Ray Tracing method is found to be very fast for surface configurations and obstruction densities typical of space structures, and it is shown to be best suited to views of J from I which are relatively simple and cover only a few subareas of S. R.R.

A86-49621*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID DROPLET RADIATOR PROGRAM AT THE NASA LEWIS RESEARCH CENTER
A. F. PRESLER, C. E. COLES, P. S. DIEM-KIRSOP, and K. A. WHITE, III (NASA, Lewis Research Center, Cleveland, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p. Previously announced in STAR as N86-12246. refs
(ASME PAPER 86-HT-15)

The NASA Lewis Research Center and the Air Force Rocket Propulsion Laboratory (AFRPL) are jointly engaged in a program for technical assessment of the Liquid Droplet Radiator (LDR) concept as an advanced high performance heat ejection component for future space missions. NASA Lewis has responsibility for the technology needed for the droplet generator, for working fluid qualification, and for investigating the physics of droplets in space; NASA Lewis is also conducting systems/mission analyses for potential LDR applications with candidate space power systems. For the droplet generator technology task, both micro-orifice fabrication techniques and droplet stream formation processes have been experimentally investigated. High quality micro-orifices (to 50 micron diameter) are routinely fabricated with automated equipment. Droplet formation studies have established operating boundaries for the generation of controlled and uniform droplet streams. A test rig is currently being installed for the experimental verification, under simulated space conditions, of droplet radiation heat transfer performance analyses and the determination of the effect radiative emissivity of multiple droplet streams. Initial testing has begun in the NASA Lewis Zero-Gravity Facility for investigating droplet stream behavior in microgravity conditions. This includes the effect of orifice wetting on jet dynamics and droplet formation. Results for both Brayton and Stirling power cycles have identified favorable mass and size comparisons of the LDR with conventional radiator concepts. B.W.

A86-50115* Maryland Univ., College Park.
THERMAL STRESSES IN COMPOSITE TUBES
M. W. HYER (Maryland, University, College Park) IN: International Symposium on Composite Materials and Structures, Beijing, People's Republic of China, June 10-13, 1986, Proceedings . Lancaster, PA, Technomic Publishing Co., Inc., 1986, p. 246-251. (Contract NAG1-343)

This paper summarizes work to determine the thermally-induced stresses and deformations in specially-constructed angle-ply composite tubes subjected to a uniform temperature change relative to their stress-free cure state. The tubes are designed for application to space structures and have high axial stiffness. Four angle-ply designs are examined in an effort to determine which design might have the most favorable thermally-induced response. A planar elasticity solution is used, the solution being valid away from the ends of the tube. Of the four designs considered, none has any particular advantage as far as stress levels are concerned. However, despite the fact that the tube wall is a balanced laminate, one design exhibits a significant amount of thermally-induced twist. Author

N86-22618# Du Pont (UK) Ltd., Stevenage (England).
MULTILAYER PRINTED CIRCUIT BOARD CHARACTERIZATION BY THERMAL ANALYSIS
J. N. LECKENBY *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 215-222 Nov. 1985 refs Sponsored by International Computers Ltd., Kidsgrove, England and Fortin Industries Inc., Sylmar, Calif. Avail: NTIS HC A13/MF A01

Thermal analysis techniques used to test multilayer printed circuit boards are described. Differential scanning calorimetry laminate cure determination; thermomechanical analysis (TMA) delamination testing; gel time and resin flow determination by TMA; dynamic mechanical analysis (DMA) prepreg cure determination; cured laminate determination by DMA; thermogravimetric analysis (TGA) compositional analysis; and thermal stability kinetic studies by TGA are covered. Author (ESA)

N86-22628# European Space Agency, Paris (France).
SPACE ENVIRONMENT SIMULATION TO TEST SATELLITE THERMAL CONTROL COATINGS. VOLUME 2, APPENDIX 1: DETAILED RESULTS OF OPTICAL MEASUREMENTS MADE AFTER THE VARIOUS STAGES OF THE FIRST TEST
Aug. 1985 139 p Transl. into ENGLISH of 'Essais de Simulation d'Environmentale Spatial sur Revetements de Controle Thermique de Satellites. Tome 2, Annexe 1: Resultats Detailles des Mesures Optiques Effectuees apres les Diverses Etapes du Premier Test" Rept. CERT-4128-Vol-2-App-1 Centre d'Etudes et de Recherche de Toulouse, France Original language document was announced as N85-17013 3 Vol.
(ESA-TT-891-VOL-2; CERT-4128-VOL-2-APP-1) Avail: NTIS HC A07/MF A01

Simultaneous irradiation of satellite thermal control coatings by electrons, protons, and ultraviolet radiation, simulating 5 yr in geostationary orbit, was carried out. A layer of contaminant, originating from adhesive RTV566 by molecular flux, was applied to samples under controlled conditions. Changes were followed by microbalances and by measurements of optical reflectance over the spectrum. Results for optical measurements before deposition and for 0.2, 0.5, and 1 yr after are presented. Author (ESA)

N86-22629# European Space Agency, Paris (France).
SPACE ENVIRONMENT SIMULATION TO TEST SATELLITE THERMAL CONTROL COATINGS. VOLUME 2: APPENDICES 2, 3, AND 4. APPENDIX 2: DETAILED RESULTS OF OPTICAL MEASUREMENTS MADE AFTER THE VARIOUS STAGES OF THE SECOND TEST. APPENDIX 3: SUMMARY OF OPTICAL RESULTS OBTAINED DURING THE FIRST TEST. APPENDIX 4: SUMMARY OF OPTICAL RESULTS OBTAINED DURING THE SECOND TEST
Aug. 1985 259 p refs Transl. into ENGLISH of 'Essais de Simulation d'Environentale Spatial sur Revetements de Controle Thermique de Satellites. Tome 2: Annexe 2: Resultats Detailles des Mesures Optiques Effectuees apres les Diverses Etapes du Deuxieme Test. Annexe 3: Recapitulatif des Essais Optiques au Cours du Premier Test. Annexe 4: Recapitulatif des Mesures Optiques Effectuees au Cours du Deuxieme Test" Rept. CERT-4128-Vol-2-App-2-App-3-App-4 Centre d'Etudes et de Recherche de Toulouse, France Original language document was announced as N85-17014 3 Vol.
(ESA-TT-891-VOL-3; CERT-4128-VOL-2-APP-2,3,4) Avail: NTIS HC A12/MF A01

Simultaneous irradiation of satellite thermal control coatings by electrons, protons, and ultraviolet radiation, simulating 5 yr in geostationary orbit, was carried out. A layer of contaminant, originating from adhesive RTV566 by molecular flux, was applied to samples under controlled conditions. Changes were followed by microbalances and by measurements of optical reflectance over the spectrum. Results at minus 35 and plus 2 C for up to 5.08 yr after deposition are presented. Author (ESA)

N86-23623*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ANALYSIS OF A SINGLE-FOLD DEPLOYABLE TRUSS BEAM PRELOADED BY EXTENSION OF SELECTED FACE DIAGONAL MEMBERS
K. C. WU and M. S. LAKE Apr. 1986 17 p refs
(NASA-TM-87673; NAS 1.15:87673) Avail: NTIS HC A02/MF A01 CSCL 22B

A technique for preloading a deployable box truss beam by extension of one face diagonal per bay was studied to determine if it would result in uniform loading of truss joints without causing excessive truss deformations. Results indicate that it is possible to accomplish uniform loading in the beam region way from beam boundaries, whereas in the regions near boundaries the member loading becomes non-uniform with magnitudes greater than those in the uniform load region. Also, the type of deformation which results in the beam depends on the pattern of preloaded members. Author

N86-23631# Texas A&M Univ., College Station.
A MODEL FOR PREDICTING THERMOMECHANICAL RESPONSE OF LARGE SPACE STRUCTURES Annual Technical Report, May 1984 - Apr. 1985
D. H. ALLEN and W. E. HAISLER Jun. 1985 196 p
(Contract F49620-83-C-0067)
(AD-A162139; MM-4875-85-11; AFOSR-85-1016TR) Avail: NTIS HC A09/MF A01 CSCL 22B

A model is being developed for predicting the thermomechanical response of large space structures to cyclic transient temperature loading conditions. The research is being conducted in the following stages: (1) selection and specialization of thermomechanical constitutive equations to be utilized in the analysis of large space structures; (2) construction (where necessary) of coupled energy balance equations (modified Fourier heat conduction equations) applicable to the constitutive models selected in item (1); (3) casting (where necessary) the resulting field laws into coupled and uncoupled variational principles suitable for use with the finite element method; (4) finite element discretization of the variational principles for several element types; (5) experimentation to determine material properties to be utilized in the constitutive models; and (6) parametric studies of the quasistatic and dynamic response of large space structures undergoing thermomechanically and environmentally degraded material properties. GRA

N86-24730*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
GENERALIZED PARITY RELATIONS FOR LARGE SPACE STRUCTURES WITH UNCERTAIN PARAMETERS M.S. Thesis
J. R. DUTILLOY Jan. 1986 72 p refs
(Contract NAG1-126)
(NASA-CR-176762; NAS 1.26:176762; REPT-2-86) Avail: NTIS HC A04/MF A01 CSCL 22B

The generalized parity relations method is a technique that can be used to detect sensor and actuator failures on a large space structure. A model of a grid structure was used to evaluate the performance of these relations. It shows their relative sensitivity to modeling errors. A method using sensor outputs and actuator inputs is required for the design of the generalized parity relations. Three different estimators are studied. The last estimator can generate relations optimized for the detection of a particular failure which are interesting when the level of sensor noise is high. E.A.K.

N86-24731*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURAL PERFORMANCE OF SPACE STATION TRUSSES WITH MISSING MEMBERS
J. T. DORSEY May 1986 35 p refs
(NASA-TM-87715; NAS 1.15:87715) Avail: NTIS HC A03/MF A01 CSCL 22B

Structural performance of orthogonal tetrahedral and Warren-type full truss beams and platforms are compared. In addition, degradation of truss structural performance is determined for beams, platforms and a space station when individual struts are removed from the trusses. The truss beam, space station, and truss platform analytical models used in the studies are described. Stiffness degradation of the trusses due to single strut failures is determined using flexible body vibration modes. Ease of strut replacement is assessed by removing a strut and examining the truss deflection at the resulting gap due to applied forces. Finally, the reduction in truss beam strength due to a missing longeron is determined for a space station transverse boom model. Author

N86-27380# Spar Aerospace Ltd., Ste-Anne-de-Bellevue (Quebec).
DESIGN AND TEST OF A LINEAR THERMAL ACTUATOR
G. BUSH, D. OSBORNE, and V. A. WEHRLE *In* ESA Second European Space Mechanisms and Tribology Symposium p 181-185 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

A linear thermal actuator (LTA) to serve as the actuating element of a shape control system which compensates actively for deployment inaccuracies or thermal distortions of large antennas or other space structures requiring high dimensional stability was developed. The LTA was subjected to spacecraft-level vibration and thermal vacuum tests. Results and effect on ambient performance are presented. A follow-on development effort in which it is proposed to incorporate a network of distributed LTAs into a shape control system for a phased-array planar antenna of a hypothetical ice surveillance satellite is outlined. ESA

N86-27652*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SHUTTLE TETHERED AEROTHERMODYNAMICS RESEARCH FACILTY (STARFAC) INSTRUMENTATION REQUIREMENTS
G. M. WOOD, P. M. SIEMERS, G. M. CARLOMAGNO (Naples Univ. (Italy).), and J. HOFFMAN (Texas Univ., Dallas.) *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 251-263 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

The instrumentation requirements for the Shuttle Tethered Aerothermodynamic Research Facility (STARFAC) are presented. The typical physical properties of the terrestrial atmosphere are given along with representative atmospheric daytime ion concentrations and the equilibrium and nonequilibrium gas property comparison from a point away from a wall. STARFAC science and engineering measurements are given as are the TSS free stream gas analysis. The potential nonintrusive measurement techniques for hypersonic boundary layer research are outlined along with the quantitative physical measurement methods for aerothermodynamic studies. E.R.

N86-27653*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SHUTTLE TETHERED AEROTHERMODYNAMICS RESEARCH FACILITY (STARFAC)
P. M. SIEMERS, G. M. WOOD, and H. WOLF *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 265-285 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

The Earth's atmosphere from 90 km to 200 km provides the last aerothermodynamics frontier. Present NASA programs which require but also can provide an understanding of the aerodynamics and aerothermodynamics of the free molecule and transition flows that exist at these altitudes are the Aeroassisted OTV, Entry Research Vehicle and the Tethered Satellite. Each of these programs provides a unique opportunity to do flight research in the rarefied upper atmosphere. However, the Tethered Satellite Program provides, because of its capability to obtain global, in-situ, steady state data, the greatest potential to: (1)define the performance of aerodynamic shapes as a function of environmental characteristics (free molecule, transition, slip flow regimes); (2)define the characteristics of the upper atmosphere and the global variability of properties such as composition temperature, pressure and density. Such data are required to accomplish the systematic development and verification of analytical prediction techniques required to support advance configuration designs. Author

N86-27677 Stanford Univ., Calif.
THERMAL AND ELECTROMAGNETIC DAMPING ANALYSIS AND ITS APPLICATION Ph.D. Thesis
L. USIK 1985 308 p
Avail: Univ. Microfilms Order No. DA8511326

Passive damping techniques, as a part of vibration control, have been researched extensively during the past decade to gain successful performance of vibrating systems by reducing undesirable vibrations. Most of the research has been focussed on artificially furnished damping which is relatively larger than material damping. Large space structures require light-weight construction with extremely accurate positioning requirements. Even a tiny amount of material damping has been recognized as essential for meeting such requirements of large space structures such as telescopes and attennas in space. The purpose of this research is to estimate analytically the thermal damping due to thermal currents and the electromagnetic damping due to electric conduction currents based on coupled thermoelasticity and coupled magnetoelasticity. Also, the influence of thermal damping on the aeroelastic stabilities is investigated based on the theory of two-dimensional aerodynamics. In this research the study of effects of structural and geometrical constraints on damping loss factors are investigated. Optimum conditions for the maximum damping, which may be useful on the stage of system design, are investigated. Dissert. Abstr.

N86-28427*# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. Fisica Spazio Interplanetario.
SPONTANEOUS RADIATION EMITTED BY MOVING TETHERED SYSTEMS
M. DOBROWOLNY *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 431-439 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

Some concepts related to radiation emitted by a large conductor moving through a magnetoplasma are outlined and referred to the case of long tethers. Some recent results of a theoretical calculation of Alfven wings, their structure and the power associated with are shown. How the problem of radiation from TSS or for any large conductor moving through a magnetoplasma should be

approached is presented. The approach is that of the theory of antennas in plasmas. E.R.

N86-28984*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTEGRATED THERMAL-STRUCTURAL-ELECTROMAGNETIC DESIGN OPTIMIZATION OF LARGE SPACE ANTENNA REFLECTORS
H. M. ADELMAN and S. L. PADULA Jun. 1986 18 p Presented at the 27th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics and Materials Conference, San Antonio, Tex., 19-21 May 1986
(NASA-TM-87713; NAS 1.15:87713) Avail: NTIS HC A02/MF A01 CSCL 22B

The requirements for low mass and high electromagnetic (EM) performance in large, flexible space antenna structures is motivating the development of a systematic procedure for antenna design. In contrast to previous work which concentrated on reducing rms distortions of the reflector surface, thereby indirectly increasing antenna performance, the current work involves a direct approach to increasing electromagnetic performance using mathematical optimization. The thermal, structural, and EM analyses are fully integrated in the context of an optimization procedure, and consequently, the interaction of the various responses is accounted for directly and automatically. Preliminary results are presented for sizing cross-sectional areas of a tetrahedral truss reflector. The results indicate potential for this integrated procedure from the standpoint of mass reduction, performance increase, and efficiency of the design process. Author

N86-30774# Royal Inst. of Tech., Stockholm (Sweden). Dept. of Aeronautical Structures and Materials.
THERMAL STABILITY OF SANDWICH REFLECTORS
H. GROTH *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 133-139 Feb. 1986 Sponsored by Ericsson Radio System
Avail: NTIS HC A16/MF A01

The inplane coefficient of thermal expansion (CTE) of the honeycomb sandwich of a spacecraft antenna reflector was treated using an analytical model, where the panel is treated like a sandwich panel, and an approach using the finite element method. Both methods are based on linear elasticity. For the first model the influence of different sandwich parameters is discussed. For the second model, the CTE is calculated for a typical panel, and results are compared with the first model. A difference between the two models is explained by the behavior of the honeycomb core. In the analytical model the core and the faces are assumed to keep their initial shape, i.e., no bending or out of plane deformations of the honeycomb cell walls or of the faces. The analytical model may therefore serve as an upper bound solution of the thermal expansion of the panel. ESA

N86-30775# European Space Agency, Paris (France). Mechanical Systems Div.
DIMENSIONAL STABILITY OF CFRP TUBES FOR SPACE STRUCTURES
G. G. REIBALDI *In its* Proceedings of a Workshop on Composites Design for Space Applications p 141-147 Feb. 1986
Avail: NTIS HC A16/MF A01

Dimensional stability of CFRP tubes used in spacecraft structures was investigated as a function of the number of thermal cycles. Length and weight decrease with the number of cycles. Thermal cycling generates microcracking, which increases desorption rate for the weight and length. For the SPAS tube T006 the length increases with respect to the initial value, probably due to large microcracking. The polythene bag does not influence the absorption rate. No clear asymptotic value for the weight and length variation with the increasing of thermal cycles is found. Permanent deformations are expected in orbit, about 25 microns after 300 thermal cycles. Lay-up of the CFRP tube is important for dimensional stability. A CIBA-GEIGY tube shows lower length variation, even if the weight loss is similar to that of the SPAS. ESA

N86-30798# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
STRUCTURAL ANALYSIS, MANUFACTURING AND TEST EVALUATION OF A POLARIZATION SENSITIVE REFLECTOR
W. WEISS, K. PFEIFER, and R. LEITNER *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 337-347 Feb. 1986
(Contract ESTEC-5494/84-NL(CM))
Avail: NTIS HC A16/MF A01

A parabolic reflector for space applications was developed. The reflector consists of two Kevlar/Nomex sandwich shells with a diameter of 1100 mm. Their edges are connected by a Kevlar/glass ring. The rear shell is fixed to the satellite by a conical carbon fiber composite cylinder and stiffened by four Kevlar/Nomex ribs. To minimize the thermal stresses the thermal expansion coefficients were adjusted to the reflector shells. In the static analysis a finite element calculation was performed for an acceleration of 15 g and for the most critical Sun irradiation with a partly shadowed reflector. All stresses are below the strength limits. The antenna was tested by sine vibration, acoustic noise, thermal cycling, and solar simulation without failure. ESA

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STRUCTURAL DYNAMICS AND CONTROL

Includes modeling, systems identification, attitude and control techniques and systems, surface accuracy measurement and control techniques and systems, sensors, and actuators.

A86-31024#
THERMALLY-INDUCED VIBRATION AND STABILITY OF BOOMS WITH OPEN CROSS SECTION CAUSED BY UNIDIRECTIONAL RADIANT HEATING
M. MUROZONO, Y. HASHIMOTO, and S. SUMI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 383, 1985, p. 719-727. In Japanese, with abstract in English. refs

A long extensible spacecraft boom subjected to solar radiant heating is modelled as a thin-walled long cylinder of split nonoverlapping sections. A tip mass is attached to one end which is free to wrap, while the other end is fixed. The boom is heated by unidirectional solar radiation normal to the longitudinal axis. The equation of thermally-induced torsional vibration in the system is formulated by considering the coupling effect of mechanical and thermal phenomena as a one-degree-of-freedom system. The characteristic equation is evaluated using the Routh-Hurwitz stability criterion, and it is found that the stability characteristics are dependent upon the direction of radiant heating as well as on the three system parameters. The boundary curves, which divide the parameter plane into regions of stability and instability according to the direction of radiation, and some typical responses based on the closed-form solution, are also given. C.D.

A86-31651#
SPACECRAFT ATTITUDE DYNAMICS AND CONTROL - A PERSONAL PERSPECTIVE ON EARLY DEVELOPMENTS
P. LIKINS (Lehigh University, Bethlehem, PA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 129-134. refs

This paper represents the personal perspective of one observer and participant in the evolution of the field of spacecraft attitude dynamics, stabilization, and control. The first lessons in the attitude stability of spinning spacecraft are related to the launch of Explorer I. A natural extension to the spinning satellite involved the attachment of a 'despun platform', using a closed-loop control system with a torque motor to maintain the desired relative rotation rate of 'rotor' and 'platform'. The first of the dual-spin spacecraft was the Orbiting Solar Observatory. It is pointed out that dual-spin spacecraft have provided some of the most intriguing dynamics

and control problems in the evolution of spacecraft attitude dynamics. Attention is also given to developments related to gravity-stabilized satellites, actively controlled spacecraft, and implications of the discussed events for engineering education. G.R.

A86-31664#
UNIFORM DAMPING CONTROL OF SPACECRAFT
L. SILVERBERG (North Carolina State University, Raleigh) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 221-227. refs

This paper introduces the uniform damping control of flexible spacecraft. The dynamic characteristics of spacecraft are reviewed and a criterion for dynamic performance is described by a uniform damping control approach which exhibits three distinctly attractive features. It is shown that (1) the associated uniform damping control law is independent of the spacecraft stiffness, (2) the associated control forces are proportional to the spacecraft mass density, and (3) the uniform damping control law is decentralized. The uniform damping control solution is shown to represent a first-order approximation to a special globally optimal control problem. Also, the implementation of uniform damping control is considered using discrete (in space) actuation and sensing type devices. Robustness in the presence of errors due to implementing the control using discrete components is characterized. Author

A86-31665#
ROBUST BEAM-POINTING AND ATTITUDE CONTROL OF A FLEXIBLE SPACECRAFT
J. S.-C. YUAN (Spar Aerospace, Ltd., Toronto, Canada) and M. E. STIEBER (Department of Communications, Ottawa, Canada) (Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers, p. 688-695) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 228-234. Sponsorship: Department of Supply and Services of Canada. Previously cited in issue 22, p. 3239, Accession no. A85-45950. refs
(Contract DSS-06ST-36001-3-2484)

A86-31666#
VARIABLE-STRUCTURE CONTROL OF SPACECRAFT LARGE-ANGLE MANEUVERS
S. R. VADALI (Iowa State University of Science and Technology, Ames) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 235-239. Research supported by the Iowa State University of Science and Technology. refs

The spacecraft large-angle maneuver problem is treated using the principles of variable-structure control theory. A control law that constrains the state to follow a specified path (the so-called sliding mode) in the state-space is designed on the basis of a simplified model of the spacecraft dynamics. The sliding mode is obtained by solving an optimal control posed in a reduced space, the solution being the angular velocities of the spacecraft as functions of the attitude variables (Euler parameters or quaternions in the present context). It is shown that the motion along the sliding mode is insenstive to parameter variations and unmodeled effects. Author

A86-31668#
COMPENSATING STRUCTURE AND PARAMETER OPTIMIZATION FOR ATTITUDE CONTROL OF A FLEXIBLE SPACECRAFT
D. C. CEBALLOS (Instituto de Pesquisas Espaciais, Sao Josedos Campos, Brazil) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 248, 249. refs

In this paper, a feedback double path compensating (FDPC) control structure is considered for the attitude control of a flexible spacecraft, where vibration modes and modeling errors are present. It is pointed out that the basic idea involved in the FDPC scheme is related to the nullification of the accumulated effect of the truncated modes and the modeling errors. A parameter optimization procedure is applied to find the gains for the FDPC structure. Attention is given to the gain selection procedure and the application of the considered approach to a flexible spacecraft. It is found that the discussed double-path compensating controller can satisfy the requirements of performance, sensitivity to modeling errors, and simplicity for onboard implementation. G.R.

A86-31781* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PAYLOAD ISOLATION AND PRECISION POINTING FOR THE 1990'S
S. W. SIRLIN and R. A. LASKIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Guidance and control 1985; Proceedings of the Eighth Annual Rocky Mountain Conference, Keystone, CO, February 2-6, 1985 . San Diego, CA, Univelt, Inc., 1985, p. 39-60. NASA-supported research. refs
(AAS PAPER 85-010)

The design of a pointing system that is applicable for a variety of payloads is examined. The system employs a very soft interface coupled with inertial control torques which use reaction wheels or control moment gyros. The fundamental stability and disturbance rejection characteristics of simple gimbal pointing systems and the soft mounted inertially reacting concept are evaluated and compared. It is observed that in simple and two-stage gimbal systems there is dynamic interaction with the basebody and these types of systems are not applicable for a Space Station/Space Platform environment in which system dynamics are uncertain; however, the soft mounted inertially reacting concept minimizes the dynamic interaction with the basebody and retains stability. It is concluded that the soft mounted inertially reacting concept has the pointing accuracy and disturbance isolation of a free flying spacecraft while still obtaining power, communication, orbit maintenance, and servicing from a basebody. I.F.

A86-31794* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ORBITAL MANEUVERING VEHICLE GUIDANCE, NAVIGATION AND CONTROL
W. G. HUBER and W. FINNELL, III (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Guidance and control 1985; Proceedings of the Eighth Annual Rocky Mountain Conference, Keystone, CO, February 2-6, 1985 . San Diego, CA, Univelt, Inc., 1985, p. 285-295.
(AAS PAPER 85-043)

This paper describes the Orbital Maneuvering Vehicle (OMV) concept and its intended role. It recaps the past activities leading up to the current concept and summarizes the present status and plans. The various types of missions and operating modes required by the OMV are described as the basis of the guidance, navigation and control (GN&C) requirements. The general GN&C problem is outlined with potential hardware solutions. Author

A86-31795* Rutgers - The State Univ., Piscataway, N. J.
THE GALILEO SCAN PLATFORM POINTING CONTROL SYSTEM - A MODERN CONTROL THEORETIC VIEWPOINT
G. E. SEVASTON (Rutgers University, Piscataway, NJ), G. A. MACALA, and G. K. MAN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Guidance and control 1985; Proceedings of the Eighth Annual Rocky Mountain Conference, Keystone, CO, February 2-6, 1985 . San Diego, CA, Univelt, Inc., 1985, p. 297-321. refs
(AAS PAPER 85-044)

The current Galileo scan platform pointing control system (SPPCS) is described, and ways in which modern control concepts could serve to enhance it are considered. Of particular interest are: the multi-variable design model and overall control system architecture, command input filtering, feedback compensator and command input design, stability robustness constraint for both continuous time control systems and for sampled data control systems, and digital implementation of the control system. The proposed approach leads to the design of a system that is similar to current Galileo SPPCS configuration, but promises to be more systematic. K.K.

A86-31796
SINGLE-STEP OPTIMAL CONTROL OF THE RPL EXPERIMENT
M. A. FLOYD (Integrated Systems, Inc., Palo Alto, CA) IN: Guidance and control 1985; Proceedings of the Eighth Annual Rocky Mountain Conference, Keystone, CO, February 2-6, 1985 . San Diego, CA, Univelt, Inc., 1985, p. 323-350. Research supported by the Fannie and John Hertz Foundation. refs
(Contract F04611-82-K-0037)
(AAS PAPER 85-045)

This paper presents a control strategy which is applicable to a broad class of large space structure control problems. The considered strategy makes it possible to handle diverse sets of control inputs, including on-off thrusters and linear-limited actuators, either individually or simultaneously. Attention is given to aspects of single-step optimal control, the selection of the state weighting matrix, rigid body mode costs for large angle slews using on-off thrusters, the acceleration phase, the deceleration/terminal phase, acceleration to deceleration phase transition logic, flexible mode costs, control input lumping, a description of the experiment, simulation results, and experimental results. G.R.

A86-32940#
DAMPING SYNTHESIS FOR A SPACECRAFT USING SUBSTRUCTURE AND COMPONENT DATA
K. W. LIPS and F. R. VIGNERON (Department of Communications, Ottawa, Canada) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 497-506) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Mar.-Apr. 1986, p. 158-164. Previously cited in issue 13, p. 1847, Accession no. A84-31739. refs

A86-32944*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EXTENSION FOR GROUND-BASED TESTING FOR LARGE SPACE STRUCTURES
B. K. WADA, C. P. KUO, and R.J. GLASER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) (Structure, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 477-483) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Mar.-Apr. 1986, p. 184-188. NASA-supported research. Previously cited in issue 13, p. 1852, Accession no. A85-30375. refs

A86-33204
CONTROLLER DESIGN OF FLEXIBLE SPACECRAFT ATTITUDE CONTROL
S. MANABE (Mitsubishi Electric Corp., Kamakura Works, Japan) and K. TSUCHIYA (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan) IN: A bridge between control science and technology. Volume 5 . Oxford and New York, Pergamon Press, 1985, p. 2939-2944. refs

A controller design method for flexible spacecraft attitude control is presented. The design method uses the frequency domain approach. The system is first described by partial differential equation with internal damping model. Then the frequency response is analyzed, and the three basic characteristics of the flexible system, namely, average function, lower bound and upper bound are defined. A compensator design method is proposed on the basis of these characteristics. The result shows that the direct velocity feedback combined with weak lag networks seems to be the optimum in the sense that the bandwidth required for the actuator is the narrowest. This approach is very robust and immune to the parameter changes such as mode frequency variations. This is because the design method is based on only the general information of flexible structure and not on the specific ones. Some experiment is performed to investigate the validity of the method. Author

A86-33254* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STIFFNESS CONTROL OF LARGE SPACE STRUCTURES
J.-C. CHEN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) and J. L. FANSON (California Institute of Technology, Pasadena) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 368-373. NASA-sponsored research. refs

A method of using internal force producing dual element/actuators for vibration suppression of large space structures is proposed. This technique is applied to a vibrating string as well as a low order system. Response feedback control for the vibrating string and selected modal control are used for achieving the modal damping. The actuators used in this method may be electrically powered and are suitable for structures with extremely low rigidity. Author

A86-33255
ASPECTS OF ACTIVE ISOLATION AS APPLIED TO A SATELLITE STRUCTURE WITH SHAPE PRECISION PAYLOAD
W. CHARON (Dornier System GmbH, Friedrichshafen, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 374-380. Sponsorship: European Space Research and Technology Centre. refs
(Contract ESTEC-5326/83-NL-PB(SC))

Future large space structures need, as precision payloads, active control of vibration because of their very low eigenfrequencies. This paper investigates some aspects of the first step in active isolation design. In this first step, the satellite structure is divided into two rigid modules: the shape precision payload and a vibrating equipment module containing the attitude sensors and the attitude actuators. The two modules are connected by six spring-force actuator devices which are considered here together to determine the isolation control forces. These connections transmit the low-frequency attitude control to the precision payload but attenuate the higher-frequency disturbances whose shape and magnitude are here unknown to the isolation control system. Author

A86-33284* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TEST AND ANALYSIS CORRELATION FOR STRUCTURAL DYNAMIC SYSTEMS
B. K. WADA and J.-C. CHEN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 632-647. NASA-supported research. refs

In this paper the authors summarize the activities at the Jet Propulsion Laboratory (JPL) in modifying the structural mathematical model to correlate with its modal test results. In addition to the results from the Viking and Galileo spacecrafts, developments in the parameter estimation of structural mathematical models of large flexible structures using Multiple Boundary Condition Tests (MBCT) are presented. Author

A86-33285* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC VERIFICATION OF VERY LARGE SPACE STRUCTURES
B. R. HANKS (NASA, Langley Research Center, Hampton, VA) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 648-655. refs

The dynamic verification of spacecraft relies heavily on ground-based tests. These tests usually simulate flight environments or validate analytical models used in establishing

design loads and in designing control algorithms. They also provide security against failures resulting from unanticipated or unmodeled hardware behavior. Future orbital antennas, space stations, and solar power systems are likely to be of sizes difficult to test using current ground test technology. In addition to size, other factors such as low natural frequencies, lightweight construction, and the presence of many structural joints, cause significant sensitivity of the test process to the earth-gravity environment. Yet, accuracy requirements on the verification process will be more stringent because of modern flexible-structure control approaches. This paper describes some of the problems and discusses research on potential solutions. The importance of an integrated ground test, analysis, and flight test program is emphasized. An ongoing research program of this type focusing on a 60-meter, deployable, truss-beam test article is described. Author

A86-33288
LOW FREQUENCY DESIGN VERIFICATION OF LARGE SPACECRAFT STRUCTURES
E. ERBEN and K. ECKHARDT (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 672-682. Research sponsored by the European Space Research and Technology Centre and INTELSAT.

Current trends in spacecraft structural technologies toward greater complexity, modularity and novel launcher systems call for a structural design verification process using a multiaxis vibration system (MAVIS) and transient input functions. Attention is given to MAVIS' application to such physical and practical aspects as hardware model philosophy and performance requirements. An existing satellite structure could be used as the basis for initial experiences with multiaxis transient testing. O.C.

A86-33289
VIBRATION QUALIFICATION AT THE DAVID FLORIDA LABORATORY
R. MAMEN (Department of Communications, David Florida Laboratory, Ottawa, Canada) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 683-688.

The David Florida Laboratory, a national facility for spacecraft integration and environmental test, provides the support required to qualify flight hardware for a wide range of Canadian and export projects. Its thermal vacuum, mass properties, radio frequency and vibration testing services are used by a growing list of aerospace companies and government departments for programs ranging from black box level to complete spacecraft and space systems. Its comprehensive structural qualification capabilities were selected for the remote manipulator system ('CANADARM'), ANIK-D and Brazilsat and for L-Sat ('OLYMPUS'). The facilities and staff skills are being improved significantly, in order to facilitate the qualification of larger and more complex structures. Author

A86-35212* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
MASS PROPERTY CONTROL OF A SPIN STABILIZED SPACECRAFT WITH RESTRICTIVE MISSION AND WEIGHT CONSTRAINTS
W. E. LANG (NASA, Goddard Space Flight Center, Greenbelt, MD) and C. ARDVINI (Roma II, Universita, Rome, Italy) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 26 p.
(SAWE PAPER 1668)

In the primary experiment of the spin stabilized San Marco D/L spacecraft, the drag effects on a light spherical shell coupled to a relatively massive center body will be measured. To achieve the precise mass property control, the centroids of both the shell and the center body must coincide with each other and with the center of pressure of the shell. Precise spin balancing is needed for launch and orbital stability, and the deployable antennas need accurate alignment. Corrective measures, developed after the preliminary mass measurements showed flaws in the mass property control, are described in detail. Inertia booms and a yo-yo despin system were developed as add-on units, spin balance measurements about all three geometric axes were used to define weight minimized correction within the outer shell envelope, and boom tip mass differentials were optimized for the most favorable inertia ratio margin achievable within the mission weight constraints. The weight versus orbital lifetime trade-offs were also considered. I.S.

A86-35333* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AN INVESTIGATION OF ADAPTIVE CONTROL TECHNIQUES FOR SPACE STATIONS
C.-H. C. IH, S. J. WANG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and C. T. LEONDES (California, University, Los Angeles) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 81-94. NASA-supported research. refs

The present paper is concerned with control problems which arise in connection with the establishment and maintenance of space stations. Some of the arising problems are related to great changes in mass and an intensive shock load accompanying Shuttle docking. Such problems can be solved by making use of a robust adaptive control system. Space station configurations developed by NASA and the corresponding mass properties are discussed along with dynamic models for space stations, aspects of problem formulation and control architecture, adaptive control algorithms, a performance analysis, and practical considerations. Attention is given to adaptive regulator control with initial transient, adaptive control during Shuttle docking, and cases involving Shuttle hard docking with model switching and disturbance modeling. G.R.

A86-35390* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TESTING OF A FAILURE ACCOMMODATION SYSTEM ON A HIGHLY FLEXIBLE GRID
R. C. MONTGOMERY and J. P. WILLIAMS (NASA, Langley Research Center, Hampton, VA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 984-989. refs

This paper presents a scheme for on-line failure detection in systems with appreciable structural dynamics. The design is suboptimal because of extensive computational requirements of optimal schemes. To accomplish failure detection, the innovations sequence of a finite order Kalman filter is examined. Because of the heavy dependence of the system on the zero-mean character of the innovations sequence of the filter much attention has been given to the design and evaluation of the Kalman filters used. The filter designs are based on modal models of the structural dynamics. Two modal models were considered, one based on an analytic finite element model and the other based on empirically derived frequency and damping. Experiments using a grid structure are presented which illustrate operation and performance of the filter designs based on these models. The general character of the results presented is that appreciable errors exist in the filter design based on the finite element model. Substantial improvement results if the design model is modified to include empirically derived frequency and damping. Author

A86-36074* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STABILITY OF MULTILOOP LQ REGULATORS WITH NONLINEARITIES. I - REGIONS OF ATTRACTION. II - REGIONS OF ULTIMATE BOUNDEDNESS
S. M. JOSHI (NASA, Langley Research Center, Hampton, VA) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. AC-31, April 1986, p. 364-370. refs

An investigation is conducted for the closed loop stability of linear time-invariant systems controlled by linear quadratic (LQ)

regulators, in cases where nonlinearities exist in the control channels lying outside the stability sector in regions away from the origin. The estimate of the region of attraction thus obtained furnishes methods for the selection of performance function weights for more robust LQ designs. Attention is then given to the closed loop stability of linear time-invariant systems controlled by the LQ regulators when the nonlinearities in the loops escape the stability sector in a bounded region containing the origin. O.C.

A86-36216
AN ORTHOGONAL DECOMPOSITION APPROACH TO MODAL SYNTHESIS
H. FLASHNER (Southern California, University, Los Angeles, CA) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 23, March 1986, p. 471-493. refs

Modal synthesis is a method of formulating the equations of motion for complex vibratory systems. This approach has many advantages in modelling systems that consist of an assembly of linear dynamic elements whose modal characteristics are given. Presented in the paper is a procedure for synthesizing linear dynamic models into one dynamic description in a numerically stable way. This task is achieved by an orthogonal co-ordinate transformation replacing the matrix inversions required when other procedures are used. The modal synthesis is formulated as a problem of finding the equations of motion for a linear system subject to a set of linear constraints. The numerical procedure to generate the equations of motion in terms of independent co-ordinates is presented. The paper concludes with several examples that demonstrate the properties of the proposed method and its application to the modeling of vibratory systems. Author

A86-37060*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONSTRUCTION AND CONTROL OF LARGE SPACE STRUCTURES
M. F. CARD, W. L. HEARD, JR. (NASA, Langley Research Center, Hampton, VA), and D. L. AKIN (MIT, Cambridge, MA) Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Paper. 21 p. refs

Recent NASA research efforts on space construction are reviewed. Preliminary results of the EASE/ACCESS Shuttle experiments are discussed. A 45-foot beam was constructed on orbit in 30 minutes using a manual assembly technique at a work station. A large tetrahedron was constructed several times using a free floating technique. The capability of repair, utilities installation, and handling the structures using a mobile foot restraint on the RMS was also demonstrated. Implications of the experiments for Space Station are presented. Models of 5-meter Space Station structure together with neutral buoyancy simulations suggest manual assembly techniques are feasible. Selected research on control of flexible structures is discussed. To support planned flight experiments, studies of the design and optimal placement of distributed active dampers are underway. Author

A86-37186* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE STATION DYNAMIC MODELING, CONTROL AND SIMULATION
C.-H. C. IH, S. J. WANG, and Y.-H. LIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 109-142. NASA-supported research. refs

Dynamic disturbances of many orders of magnitude greater than those of conventional spacecraft will be routine for the Space Station. Accurate knowledge of inflight structural dynamics and disturbances will be lacking. System identification will reduce uncertainties. To deal with the remaining model errors and time-varying elements, adaptive control may be required. Dynamic models for two Space Station configurations are derived. A direct model reference adaptive control algorithm is synthesized and evaluated with respect to the station model parameter errors and plant dynamics truncations. Both the rigid body and the flexible modes are treated. Simulation results show that convergence of the adaptive algorithm can be achieved in 100 to about 300 seconds with reasonable performance even during Shuttle hard docking operations in which station mass and inertia are instantaneously changed by more than 100 percent. Author

A86-38542
A GLOBAL TECHNIQUE FOR ESTIMATION OF MODAL PARAMETERS FROM MEASURED DATA
R. N. COPPOLINO (MacNeal-Schwendler Corp., Los Angeles, CA) and R. C. STROUD (Synergistic Technology, Inc., Cupertino, CA) IN: Structural dynamic testing and analysis; Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985, Technical Papers . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 15-23. refs
(SAE PAPER 851926)

An automated method for estimation of structural vibration modes from measured frequency response data is described. The technique simultaneously treats an ensemble of measured responses and identifies a set of linearly independent displacement patterns exhibited by the data. In addition, generalized frequency response functions associated with the independent displacement patterns are identified. An effective dynamic system described by the generalized frequency responses is deduced from least squares considerations, from which modal parameters of the structure are estimated. Author

A86-38546* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTIPLE BOUNDARY CONDITION TEST (MBCT) APPROACH TO UPDATE MATHEMATICAL MODELS OF LARGE FLEXIBLE STRUCTURES
B. K. WADA, C.-P. KUO, and R. J. GLASER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structural dynamic testing and analysis; Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985, Technical Papers . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 75-82. NASA-supported research. refs
(SAE PAPER 851933)

A major challenge to the structural dynamicist is to validate mathematical models of large space structures which cannot be ground tested because of its size and/or flexibility. The paper presents a Multiple Boundary Condition Test (MBCT) approach which allows a systematic validation of the mathematical model by performing a number of ground tests on a large structure with variable boundary conditions. A numerical simulation is presented which illustrates the validity of the MBCT including some of the potential limitations. Author

A86-38548
SYNTHESIS OF DISCRETE PASSIVE VIBRATION DAMPERS
S. S. SIMONIAN (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: Structural dynamic testing and analysis; Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985, Technical Papers . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 97-109.
(SAE PAPER 851935)

The present study is a continuation of the effort in the application of viscoelastic (VE) damping to large and flexible space systems design. In particular, this work extends the analytical passive damping predictions reported previously. The analytical study completed here relates the number of discrete joint VE dampers, in typical large and flexible space optical systems, to the overall damping of the structure. This data is crucial for the optimal blending of passive damping and active control technologies in space systems design. Author

A86-38812#
SPACE FRAME OPTIMIZATION SUBJECT TO FREQUENCY CONSTRAINTS
T. H. WOO (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 103-115. Research supported by TRW Independent Research and Development Program. refs
(AIAA PAPER 86-0877)

An efficient structural optimization methodology is presented for the design of minimum weight space frames subject to multiple natural frequency constraints. A powerful class of generalized hybrid constraint approximations which require only the first order constraint function derivatives have been developed to overcome inherent nonlinearity of the frequency constraint. The generalized hybrid constraint functions are shown to be relatively conservative, separable and convex in the region bounded by the move limits based on the formula described in this paper. The optimization methodology is implemented in an automated structural optimization system which has been applied to solve a variety of space frame optimization problems. Numerical results obtained for three example problems indicate that the optimization methodology requires fewer than 10 complete normal modes analyses to generate a near optimum solution. Author

A86-38827*# State Univ. of New York, Buffalo.
MICROPROCESSOR CONTROLLED FORCE ACTUATOR
D. C. ZIMMERMAN, D. J. INMAN (New York, State University, Buffalo), and G. C. HORNER (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 243-251. refs
(Contract NGT-33-183-801)
(AIAA PAPER 86-0916)

The mechanical and electrical design of a prototype force actuator for vibration control of large space structures (LSS) is described. The force actuator is an electromagnetic system that produces a force by reacting against a proof-mass. The actuator has two colocated sensors, a digital microcontroller, and a power amplifier. The total weight of actuator is .998 kg. The actuator has a steady state force output of approximately 2.75 N from approximately 2 Hz to well beyond 1000 Hz. Author

A86-38844#
SYNTHESIS OF STRUCTURES WITH MULTIPLE FREQUENCY CONSTRAINTS
B. P. WANG (Texas, University, Arlington) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 394-397. refs
(AIAA PAPER 86-0951)

The problem of minimum weight design with several natural frequency constraints is considered in this paper. The problem is solved using a combined finite element-sequential linear programming (SCP) formulation. The unique features of the current approach include the use of assumed mode reanalysis formulation for repeated eigensolution and the associated sensitivity analysis. Additionally, a simple adaptive move limit strategy is developed to stabilize the SLP solutions. The present approach has been implemented with general purpose finite element programs (MSC/NASTRAN and a version of SAP4) and applied to several design problems. Author

A86-38886*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC ANALYSIS AND EXPERIMENT METHODS FOR A GENERIC SPACE STATION MODEL
W. K. BELVIN (NASA, Langley Research Center, Hampton, VA) and H. H. EDIGHOFFER (Edighoffer, Inc., Newport News, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 10-18. refs
(AIAA PAPER 86-0838)

Modal vibration tests in conjunction with finite element analysis were used to characterize a generic dynamic model. The model consists of five substructures to simulate the multi-body, low frequency nature of large space structures. Static tests were used to refine the substructure analytical models prior to full assemblage analysis. The effects of a cable suspension system are analyzed using prestressed vibration analysis. Coupling between a cable suspension mode and model bending mode is shown to be influenced by the distance from the model center of gravity to the cable-to-model attachment location. A damping characterization method using noncontacting exciters was used to measure amplitude dependent damping. Frequency and damping measurements in ambient air and at near-vacuum conditions are presented. Author

A86-38887*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CHARACTERISTIC WAVE APPROACH IN CONTROLLED LARGE SPACE STRUCTURES
M. ZAK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 19-22. USAF-sponsored research. refs
(Contract NAS7-918)
(AIAA PAPER 86-0839)

The modal approach in structural dynamics usually implies a truncation technique in the course of which the contribution of high frequencies is lost. This can lead to significant error in the case of impulsive loads. As an alternative to modal (or spectral) methods, the characteristic wave approach is developed. It appears that the application of this approach is most beneficial in the domains where spectral methods fail. That is why it can be used as a supplement to modal methods when the loads contain impulsive components. Author

A86-38888#
VARIABLE STRUCTURE CONTROL SYSTEM (VSCS) MANEUVERING OF FLEXIBLE SPACECRAFT
H. OZ (Ohio State University, Columbus) and O. MOSTAFA IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 23-34. refs
(AIAA PAPER 86-0840)

Variable Structure Control Systems (VSCS) are a class of nonlinear systems which change the structure of the controls when a set of prescribed hypersurfaces are reached in the phase space. The VSCS theory has desirable insensitivity properties under parameter uncertainties, nonlinear effects and external disturbances. The theory represents a real-time implementable approach to control in contrast to algorithmic approaches, and therefore eliminates the computational burden. This paper applies the VSCS theory to maneuvering of flexible spacecraft. General nonlinear equations of motion are presented for a single axis maneuver. Three methods are presented for designing variable structure control logics. The theory is demonstrated for set point regulation, tracking, disturbance accommodation, spin-up, and robust maneuvers of a specific spacecraft configuration. Author

A86-38889#
A SINGULAR-SOLUTION APPROACH FOR CONTROLLING THE NONLINEAR RESPONSE OF A CONTINUUM MODEL OF A LARGE SPACE STRUCTURE
P. E. ODONOGHUE (Southwest Research Institute, San Antonio, TX) and S. N. ATLURI (Georgia Institute of Technology, Atlanta) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 35-42. refs
(Contract AF-AFOSR-85-0020)
(AIAA PAPER 86-0841)

The topic of vibration control of large space structures which, in this instance are modeled by equivalent continua, is addressed here. A 'singular (or fundamental) solution' approach is utilized and the control algorithm is based on a fully coupled nodal system of equations which permits the effects of non-proportional damping to be monitored. Additionally, the structure will be allowed to undergo large deformations which will necessitate the implementation of a nonlinear control algorithm. In the scheme proposed here, the calculation of the feedback control forces will be based on the feedback gain matrix obtained from a solution of the linear optimal control problem. Examples will be presented to illustrate the controllability of the vibrations in both the linear and nonlinear cases. Author

A86-38907*# Purdue Univ., West Lafayette, Ind.
A GLOBAL-LOCAL APPROACH TO SOLVING VIBRATION OF LARGE TRUSS STRUCTURES
C. T. SUN and S. W. LIEBBE (Purdue University, West Lafayette, IN) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 248-255. refs
(Contract NAG1-581)
(AIAA PAPER 86-0872)

A global-local approach was proposed to solve dynamic problems involving truss beams. A continuum Timoshenko beam was used to model sections of truss beams wherever possible and accurate. Near applied loads the continuum model was not adequate and detailed truss finite elements (discrete model) were employed. This approach was also proven efficient for an odd-shaped truss structure connected to a truss beam. Between the continuum model and the discrete model, compatibility conditions were derived. Author

A86-38914#
MODE LOCALIZATION PHENOMENA IN LARGE SPACE STRUCTURES
O. O. BENDIKSEN (Princeton University, NJ) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 325-335. refs
(AIAA PAPER 86-0903)

An analytical and numerical study is presented which investigates the possibility of localization or confinement of vibratory modes in large space structures. These structures belong to a class of periodic structures which have recently been shown to be sensitive to periodicity-breaking disorder or imperfections. When localization occurs, the modal amplitude of a global mode becomes confined to a local region of the structure, with serious implications for the control problem. The results of this study show that mode localization is most likely to occur in structures consisting of a large number of weakly coupled substructures. Certain large space structures with high modal densities fall in this category, and it is therefore important to include the effect of structural imperfections and disorder when designing control systems for shape or directional control of such structures. Author

A86-38915*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTIPLE BOUNDARY CONDITION TESTS (MBCT) FOR VERIFICATION OF LARGE SPACE STRUCTURES
B. K. WADA, C. P. KUO, and R. J. GLASER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 336-341. NASA-supported research. refs
(AIAA PAPER 86-0905)

The Multiple Boundary Condition Tests (MBCT) approach is evaluated and recent modifications are described. For the application of MBCT, 12 different boundary conditions are selected and the results of applying MBCT in conjunction with a nonlinear formulation are indicated schematically. It is concluded that the nonlinear formulation enhances the ability to implement the MBCT test approach on large space structures which cannot be ground tested without the artificial boundary conditions incorporated in MBCT. In addition, it leads to significant improvements in the convergence to the correct solution. K.K.

A86-38916*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
EQUATIONS FOR THE VIBRATION OF A SLEWING FLEXIBLE SPACECRAFT
R. D. QUINN and L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 342-354. refs
(Contract NAG1-225)
(AIAA PAPER 86-0906)

The derivation of the equations describing the vibration of a flexible spacecraft is presented in the context of a perturbation method permitting a maneuver strategy independent of the vibration control. A straightforward open-loop minimum-time rotational maneuver strategy is developed for the spacecraft regarded as a rigid body. Actuator dynamics are considered in the formulation. A maneuver force distribution is developed which excites the least amount of elastic deformation of the flexible parts of the spacecraft. An efficient technique for simulating structural vibrations during a maneuver is presented. Numerical results demonstrate the maneuver strategy and highlight the vibration caused by rotational maneuvers. Author

A86-38917*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VIBRATION OF A LARGE SPACE BEAM UNDER GRAVITY EFFECT
C.-F. SHIH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 355-361. NASA-supported research. refs
(AIAA PAPER 86-0907)

The structural characteristics of a large simply supported beam subjected to gravity are described. The nonlinear governing equations for both the static and the dynamic response are derived and solved analytically. The results show the feasibility of verifying the on-orbit dynamic characteristics of a large space beam by utilizing ground test data of such a structure. It is noted that the gravity effect interacts mostly with the first vibration mode. It was also found that the system of a large space beam subjected to its own weight is a hardening system. The differential equation for the asymmetric mode is a Duffing type equation. However, the governing equation for the symmetric mode has an additional quadratic term. It is this term that causes the maximum vibration amplitudes at different phases to be non-identical. Author

A86-38918#
SOME CONSIDERATIONS ON EARTHBOUND DYNAMIC TESTING OF LARGE SPACE STRUCTURES
H. ASHLEY (Stanford University, CA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 362-375. refs
(Contract AF-AFOSR-82-0062)
(AIAA PAPER 86-0908)

Several issues are discussed which relate to the scale-model testing, in ground facilities, of large space structures composed of beam-like elements. A comparison is made with similar tests on aeroelastic models of aircraft. With special reference to the roles of gravity, control systems and damping, it is concluded that use of large replica models will often prove infeasible. It is proposed that low-frequency beam structures under active control can furnish useful verification of design methods. This leads into various analyses of a very flexible beam hanging in gravity and of simplified models of a suspended lattice with a counterweight. By means of the latter quite low frequencies seem attainable. A mathematical appendix gives details of some of the solutions. Author

A86-38933*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MULTIDISCIPLINARY CAPABILITY FOR ANALYSIS OF THE DYNAMICS AND CONTROL OF FLEXIBLE SPACE STRUCTURES
P. A. COOPER, M. S. LAKE, J. W. YOUNG (NASA, Langley Research Center, Hampton, VA), and T. R. SUTTER (PRC-Kentron, Inc., Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 525-532. refs
(AIAA PAPER 86-0961)

The paper describes a computerized data distribution capability, IMAT, in place at the NASA Langley Research Center for the multidisciplinary analysis of the dynamics and control of large flexible space structures. The paper includes results obtained in using IMAT to investigate the influence of the structural response of the space station framework on the control of a 300kw class, solar-dynamic-powered, dual-keel space station during an orbital reboost maneuver. The method of control, using an unfiltered proportional-plus-differential control law, led to a stable control system even with local flexible response measured at the control sensor location included as a part of the control error signal. The flexible response at the outboard solar dynamic system sun-line axis was close to the maximum rotation allowed for efficient operation; thus, active local control of each solar dynamic system may be necessary to limit sun-line axis rotations effectively during a reboost maneuver. Author

A86-38951*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURAL DYNAMIC ANALYSIS OF THE LARGE DEPLOYABLE REFLECTOR
G. C. ANDERSEN and A. D. SCOTT (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics, and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986. 8 p. refs
(AIAA PAPER 86-0004)

The dynamic performance of the primary mirror of the Large Deployable Reflector (LDR) is analyzed under conditions of typical external disturbances that would be encountered during normal space operation. The performance assessment is based upon the difference between the figure distortion errors of the incoming image and the mission figure tolerance requirements (rms surface accuracy error and jitter). The need for additional figure control of the incoming image is assessed, and other alternatives for figure control are presented, such as increased structural damping effects due to the uncertainty in the real damping characteristics. V.L.

A86-39035#
THE OPTIMAL PROJECTION EQUATIONS FOR REDUCED-ORDER, DISCRETE-TIME MODELING, ESTIMATION, AND CONTROL
D. S. BERNSTEIN, L. D. DAVIS, and D. C. HYLAND (Harris Corp., Melbourne, FL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, May-June 1986, p. 288-293. refs

The optimal projection equations derived previously for reduced-order, continuous-time modeling, estimation, and control are developed for the discrete-time case. The design equations are presented in a concise, unified manner to facilitate their accessibility for the development of numerical algorithms for practical applications. As in the continuous-time case, the standard Kalman filter and linear-quadratic-Gaussian results are immediately obtained as special cases of the estimation and control results. Author

A86-39036*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF NOISE ON MODAL PARAMETERS IDENTIFIED BY THE EIGENSYSTEM REALIZATION ALGORITHM
J.-N. JUANG and R. S. PAPPA (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, May-June 1986, p. 294-303. refs

The basic concept of the Eigensystem Realization Algorithm for modal parameter identification and model reduction is extended to minimize the distortion of the identified parameters caused by noise. The mathematical foundation for the properties of accuracy indicators, such as the singular values of the data matrix and modal amplitude coherence, is provided, based on knowledge of the noise characteristics. These indicators quantitatively discriminate noise from system information and are used to reduce the realized system model to a better approximation of the true model. Monte Carlo Simulations are included to support the analytical studies. Author

A86-39037*# Brown Univ., Providence, R. I.
SPLINE-BASED DISTRIBUTED SYSTEM IDENTIFICATION WITH APPLICATION TO LARGE SPACE ANTENNAS
H. T. BANKS (Brown University, Providence, RI), P. K. LAMM (Southern Methodist University, Dallas, TX), and E. S. ARMSTRONG (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, May-June 1986, p. 304-311. refs
(Contract NAG1-258; NSF MCS-82-05355; AF-AFOSR-81-0198; NSF MCS-82-00883; NAS1-15810; NAS1-16394)

A parameter and state estimation technique for distributed models is demonstrated through the solution of a problem generic to large space antenna system identification. Assuming the position of the reflective surface of the maypole (hoop/column) antenna to be approximated by the static two-dimensional, stretched-membrane partial differential equation with variable-stiffness coefficient functions, a spline-based approximation procedure is described that estimates the shape and stiffness functions from data set observations. For given stiffness functions, the Galerkin projection with linear spline-based functions is applied to project the distributed problem onto a finite-dimensional subspace wherein algebraic equations exist for determining a static shape (state) prediction. The stiffness functions are then parameterized by cubic splines and the parameters estimated by an output error technique. Numerical results are presented for data descriptive of a 100-m-diameter maypole antenna. Author

A86-39478#
IDENTIFICATION OF A DAMPING MATRIX FROM MODEL DATA
W. L. HENDRICKSON and D. J. INMAN (New York, State University, Buffalo) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 19-26. refs

In modeling structures, the dissipation in the system is usually the most difficult element to model. This is especially true in complex arrangements such as large flexible space structures and composite materials. The work presented here examines a method of modeling the dissipation in a structure from experimental data combined with accepted nondissipation finite element data. The result of the described procedure is a linear nonconservative multiple degree of freedom model of a test structure that correctly predicts the transient response of the structure to arbitrary inputs. Author

A86-39479#
STRUCTURAL PARAMETER IDENTIFICATION USING MODAL RESPONSE DATA
N. G. CREAMER and S. L. HENDRICKS (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 27-38. refs

The identification of a set of physical structural parameters using simulated measurements of natural frequencies has been investigated to determine the minimum amount of apriori structural information required and the effects of closely spaced frequencies and model symmetry on the identification process. A necessary condition for identification is the knowledge of a mass and length scale; however, this is not always a sufficient condition. If symmetry exists in the structure, additional apriori knowledge is required. To identify the parameters of a large space structure with equal appendages using the proposed method, a sufficient condition is the knowledge of a mass and length scale for each appendage. Author

A86-39481#
NEUMANN SERIES APPROACH TO RANDOM VIBRATIONS
H. BENAROYA and M. REHAK (Weidlinger Associates, New York) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 61-76. refs
(Contract F49620-84-C-0009)

Linear, random differential equations are studied with the purpose of understanding the effects of parameter uncertainties on the random vibration of structures. In particular, a single degree-of-freedom oscillator is considered with random (stationary) stiffness and input, with deterministic, constant mass and damping. The method utilized is known as the Born expansion in physics. The mathematical formalism is based on an iterative method. The solution is of the Neumann series form. While no priori smallness assumptions are made, it becomes evident that there are restrictions in application. The restriction comes in the form of an upper bound on the variance of the stiffness parameter, i.e., its dispersion or randomness. It is demonstrated that parameter uncertainties can have an appreciable effect on the output process spectral density. The method used is complex and cumbersome, but the information derived is believed to be not otherwise available in analytic form. This framework appears useful for an initial study of random parameter systems. Author

A86-39482*# Howard Univ., Washington, D. C.
EVALUATION OF PERFORMANCE CHARACTERISTICS FOR A SPACE ANTENNA SYSTEM SUBJECTED TO STOCHASTIC DISTURBANCES
S. ANANTHAKRISHNAN, P. M. BAINUM, and A. S. S. R. REDDY (Howard University, Washington, DC) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 77-91. Research supported by Howard University. refs
(Contract NSG-1414)

Control system synthesis for a large space antenna system is investigated based on stochastic linear optimal control techniques and the minimization of a quadratic Gaussian performance index. Parametric studies indicate that suitable combinations of plant and sensor noise characteristics, and state weighting matrices, can be found to meet the mission RMS pointing requirements. Using a combination of the Kalman filter and linear feedback, an optimal control law for the finite element model of the Hoop/Column structural system without damping is obtained. Removing the hoop-mounted actuator resulted in an increase in the RMS errors, an increased control effort, and an increase in the least damped modal time constant. Removing the hoop-mounted sensor resulted in an RMS error increase and estimator performance degradation, with less system RMS performance degradation than noted for removal of the hoop-mounted actuator. R.R.

A86-39483#
STABLE DIRECT ADAPTIVE CONTROL IN HILBERT SPACE
J. WEN and M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 93-108. refs

Model Reference Adaptive Control using the command generator tracker approach has been applied successfully to some finite-dimensional systems. The same approach has also been used for adaptive regulation. The present method differs from other adaptive control algorithms in that it has potential application to infinite-dimensional systems. Four main technical difficulties for such application are discussed in this paper: coercivity of the P operator in Lyapunov Equation, the strict positive realness condition, application of the LaSalle's invariance principle in infinite dimension and the existence and the uniqueness of solution. Some of the ramifications and the remedies of these issues are investigated. Author

A86-39484#
IN SEARCH OF THE OPTIMAL QUADRATIC REGULATOR
D. W. REW (Virginia Polytechnic Institute and State University, Blacksburg) and J. L. JUNKINS (Texas A & M University, College Station) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 109-123. refs

A mathematical formulation and associated algorithm is presented which can be used to tune the weight matrices in an optimal quadratic regulator to impose constraints and eigenspace optimality criteria upon closed loop systems eigenvalues. The algorithm is found to be efficiently applicable to moderately high dimensioned problems; reliable convergence has been routinely demonstrated with over one hundred and fifty weight matrix elements being optimized to place eigenvalues in a dynamical system of order fourteen. These results provide a basis for optimism that the approach is applicable to a significant family of problems. Author

A86-39485*# Duke Univ., Durham, N. C.
FREQUENCY DOMAIN SOLUTIONS TO MULTI-DEGREE-OF-FREEDOM, DRY FRICTION DAMPED SYSTEMS UNDER PERIODIC EXCITATION
A. A. FERRI and E. H. DOWELL (Duke University, Durham, NC) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 125-144. refs
(Contract AF-AFOSR-83-0346; NAG3-516)

The anticipated low damping level in large space structures (LSS) has been a major concern for the designers of these structures. Low damping degrades the free response and complicates the design of shape and attitude controllers for flexible spacecraft. Dry friction damping has been considered as a means of increasing the passive damping of LSS, by placing it in the joints and connecting junctures of structures. However, dry friction is highly nonlinear and, hence, analytical investigations are difficult to perform. Here, a multi-harmonic, frequency domain solution technique is developed and applied to a multi-DOF, dry friction damped system. It is seen that the multi-harmonic method is much more accurate than traditional, one harmonic solution methods. The method also compares well with time integration. Finally, comparisons are made with experimental results. Author

A86-39486#
UNIFORM DAMPING CONTROL OF SPACECRAFT
L. M. SILVERBERG (North Carolina State University, Raleigh) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 145-161. refs

This paper describes the uniform damping control of flexible spacecraft. The dynamic characteristics of spacecraft are reviewed and a criterion for a dynamic performance is described by a uniform damping control which exhibits three distinctly attractive features. It is shown that (1) the associated uniform damping control law is independent of the spacecraft stiffness, (2) the associated control forces are proportional to the spacecraft mass density and (3) the uniform damping control law is decentralized. The uniform damping control solution is shown to represent a first-order approximation to a special globally optimal control problem. The implementation of uniform damping control is considered using discrete (in space) actuation and sensing type devices. Robustness in the presence of errors due to implementing the control using discrete components is characterized. Author

A86-39487#
CONTROL OF TRAVELING WAVES IN FLEXIBLE STRUCTURES
L. MEIROVITCH and J. K. BENNIGHOF (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 163-182.
(Contract AF-AFOSR-83-0017)

This paper is concerned with the control of a traveling wave in a structure by the independent modal-space control method. It is demonstrated that the control forces tend to concentrate in the immediate vicinity of the disturbance, and there are virtually no control forces acting at any point of the structure before the arrival of the disturbance. Two numerical examples are included, one for a string in transverse vibration and one for a beam in bending. Satisfactory control was achieved in spite of the fact that only a finite number of modes was retained for control. Author

A86-39488#
DEMONSTRATION OF VIBRATION CONTROL OF A FLEXIBLE TRUSS STRUCTURE
C. S. MAJOR and E. B. SHAIN (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 183-190.

A noncolocated multivariable controller for a large flexible truss structure is used to demonstrate large space structure control techniques. The structure resembles a typical optics structure single cell and supports a massive plate, representing a mirror, to which disturbances are applied using momentum exchange devices. Optical sensors detect plate motion, and linear actuators in four truss members provide control forces. A robust digital control system was designed using frequency-domain methods, and characteristic gains are used to tailor the performance characteristics. Gain margin can be predicted in spite of nonlinearities. Results demonstrate top plate disturbance reduction by a factor of 18 (25 dB) without parameter estimation, and modeling error and actuator bearing stiction are found to be the most significant performance limitation factors. R.R.

A86-39489#
FLEXIBILITY FORMULATION IN STRUCTURAL CONTROL
H. OZ (Ohio State University, Columbus) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 207-229. refs
(Contract NSF MEA-82-04920)

Structural Control is studied within the framework of 'Flexibility Formulation'. Approximate methods of structural dynamics, specifically Galerkin method, minimum quadratic equation error, point-control and collocation techniques are applied to design compatible load distribution fields for desired displacement fields. Open-loop and closed-loop derivations are presented for desired modal model behavior of the structure. It is shown that continuously distributed proportional damping and stiffness control can be affected by a finite number of point-inputs. In this regard, 'spatial modal input-distributors' are introduced as dual in control of spatial modal filters. Effects of spillover and/or spatially discrete inputs are evaluated on the basis of control design model without explicit knowledge of residual dynamics. Practical implementation is discussed and examples of feedback control are given. Author

A86-39491#
BALANCED AUGMENTED CONTROLLER REDUCTION
K. A. CARROLL and P. C. HUGHES (Toronto, University, Canada) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 245-260. refs

The problem of reducing the order of dynamic controllers is examined. An earlier method due to Yousuff and Skelton called Balanced Controller Reduction is reviewed. Their method is extended to the case where the control loop is closed. The resulting method is called Balanced Augmented Controller Reduction. Both methods are applied to the controller of a large, flexible spacecraft, ZSAT. Reduced order controllers are produced and their relative performance studied. The new method is found to perform slightly better, and applies to a larger class of controllers, than does the old method. Author

A86-39492#
FINITE DIMENSIONAL STABILIZATION OF LINEAR DISTRIBUTED PARAMETER SYSTEMS VIA GALERKIN'S TECHNIQUE
J. G. HSIEH and M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 261-273. refs

Control of the Distributed Parameter Systems (DPS) involves dynamical descriptions on infinite-dimensional Hilbert or Banach spaces of functions. Generally, it is not possible to implement an infinite-dimensional controller for the DPS. Consequently, the reduced order modeling of DPS becomes extremely crucial for design of the finite-dimensional feedback controllers. In this paper, Galerkin (or finite element) methods are presented as a way to develop finite-dimensional controllers for linear DPS. The behavior of Galerkin methods is examined, the existence of a finite-dimensional stabilizing controller for a given linear DPS is shown, and its order is specified. Author

A86-39493#
CLOSED-LOOP STABILITY OF LARGE SPACE STRUCTURES WITH REDUCED-ORDER CONTROLLERS
M. AHMADIAN (Clemson University, SC) and D. J. INMAN (New York, State University, Buffalo) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 275-289. refs

Modal truncation in the dynamic models of large space structures can cause well-known stability problems when these models are used as the design basis for active structural control. In other words, the asymptotic stability of a full-order closed-loop system cannot necessarily be ensured by the asymptotic stability of the reduced-order model. The main goal of the present study is to develop conditions which will ensure asymptotic stability of the full-order closed-loop system, when the reduced-order closed-loop system is asymptotically stable. A finite dimensional model of large space structures is exploited here to provide such conditions. These conditions are in terms of submatrices of the coefficient matrices as they are partitioned according to the modeled and residual modes. This may serve as a means of improving, or guiding, the design of a reduced-order controller. Author

A86-39494#
DYNAMICS OF GYROELASTIC VEHICLES
G. M. T. DELEUTERIO (Toronto, University, Downsview, Canada) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 291-306. NSERC-supported research. refs

A model for a flexible spacecraft having a distribution of control moment gyros and/or momentum wheels is presented. The model treats the spacecraft as a continuum in mass, stiffness and gyricity (stored angular momentum). Internal rigid-body degrees of freedom are permitted in the analysis. The equation of motion for the spacecraft is derived in operator form. Orthogonality conditions among the vibration modes are shown and the general motion is expanded in terms of these modes. As demonstrated with the aid of a simple example, the modes of gyroelastic vehicles undergo a metamorphosis of certain critical levels of gyricity. Moreover, a gyroelastic vehicle generally exhibits scleromorphic modes in which the vehicle, or part thereof (if internal rigid-body degrees of freedom are present), rotates uniformly in a deformed state. In the absence of gyricity, these modes would be uniform rotations with the vehicle undeformed. Author

A86-39495#
HOMOGENIZATION AND CONTROL OF LATTICE STRUCTURES
G. L. BLANKENSHIP (Maryland, University, College Park) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 307-324. refs
(Contract F49620-84-C-0118)

Under certain natural conditions, the dynamics of large, low-mass lattice structures with a regular infrastructure are well approximated by the dynamics of continua, e.g., trusses may be modeled by beam equations. Using a technique from the mathematics of asymptotic analysis called homogenization, it is shown how such approximations may be derived in a systematic way which avoids errors made using 'direct' averaging methods. A model is also developed for the combined problem of homogenization and control of vibrations in lattice structures, and a preliminary analysis of this problem is presented. Author

A86-39496#
A MATRIX APPROACH TO DYNAMICS FORMULATION OF COMPLEX SPACE STRUCTURES
Y. OHKAMI, O. OKAMOTO, T. KIDA, I. YAMAGUCHI, and K. MATSUMOTO (National Aerospace Laboratory, Tokyo, Japan) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 325-340. refs

A unified matrix approach for the formulation of complex space structure dynamical equations is proposed. The major advantage of the approach developed lies in its basic simplicity in solving constrained dynamical equations. It is essentially based on the formulation of a matrix algebraic equation of the form $A X = B$, to be solved for the variable X, whose elements consist of the time-derivatives of nonholonomic angular and linear momenta, followed by integration routines. The matrix A has a simple structure clarifying the characteristics of the system topology and the constraining conditions. Some examples are shown to illustrate the features of the approach, and numerical results obtained by a general-purpose computer program are presented. Author

A86-39497#
THE EFFECTS OF STRUCTURAL PERTURBATIONS ON MODAL SUPPRESSION
R. A. CALICO and S. MOORE (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 341-351. refs

The sensitivity of modal suppression to structural perturbations is considered. The stiffness matrix for the CSDL 1 model is perturbed by changing the areas of its rod members. A LQR controller, with modal suppression is designed for the nominal system. The controller is used on the perturbed systems and the effects on modal suppression are noted. The spillover into the suppressed modes due to perturbations is also quantified in terms of the change in the column space of the observation matrix. Author

A86-39498#
LINEAR REGULATOR CONTROL OF THE HOOP-COLUMN ANTENNA
A. K. CHOUDHURY, P. BOFAH, and A. R. GUMASTAS (Howard University, Washington, DC) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 353-363. refs

This paper considers the problem of linear quadratic regulator optimal control law design for a proposed deployable large space structure, the hoop-column (may-pole) antenna. A 100-meter point design hoop-column antenna is modelled as a flexible circular membrane with multiple boundary and initial conditions. Analysis

is based on near-earth equatorial circular orbit at constant angular rate. The linearised equations of motion consist of coupled rotational and generic modes. A reduced order model (using three generic modes) is used for the control law design. The main forces considered on the body are structural (which depend on the eigenfrequencies and the eigenmodes) and the earth's gravitational potential. The antenna is considered to be a linear deterministic noise-free plant. Torque actuators are designed to control the antenna shape and orientation. Author

A86-39499#
TRANSIENT DYNAMICS DURING THE EXTENSION OF FLEXIBLE MEMBERS
V. J. MODI and A. M. IBRAHIM (British Columbia, University, Vancouver, Canada) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 365-380. refs
(Contract NSERC-67-1547)

Using a rather general formulation of the problem representing a large class of space platforms with flexible, extensible members, the paper attempts to study complex interactions between deployment, attitude dynamics and flexural rigidity. The governing nonlinear, nonautonomous and coupled equations of motion are extremely difficult to solve even with the help of a computer, not to mention the cost involved. The procedure is used to study dynamics during the NASA/Lockheed Solar Array Flight Experiment (SAFE). Response of the hybrid system is obtained over a range of physical parameters and external disturbances. Both transient as well as post-deployment phases are considered. Results suggest significant influence of flexibility, inertia, deployment time history and orbital parameters on the system stability. The presence of free molecular and solar radiation induced environmental forces may further accentuate this tendency. Author

A86-39500*# California Univ., Los Angeles.
A ROBUST NONLINEAR ATTITUDE CONTROL LAW FOR SPACE STATIONS WITH FLEXIBLE STRUCTURAL COMPONENTS
P. K. C. WANG (California, University, Los Angeles) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 381-398. NASA-supported research. refs

In this paper, a nonlinear attitude control law for space stations with flexible structural components is derived using a rigid-body model. This control law, depending on the Cayley-Rodriguez parameters, globally stabilizes the equilibrium of the rigid-body model. The effect of elastic deformations of the flexible structural components on the resulting feedback system dynamics is analyzed. It is found that the system's stability property is highly robust with respect to structural vibrations and inertial variations. The time-domain behavior of the feedback system is studied numerically using a model of a typical space station with flexible solar panels. Author

A86-39501#
MODELLING OF THE HOOP-COLUMN ANTENNA AND DESIGN OF NONLINEAR CONTROL LAW IN ORBIT
P. BOFAH and A. K. CHOUDHURY (Howard University, Washington, DC) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 399-412. refs

This paper considers the problem of modeling and design of a nonlinear control law for the hoop-column antenna in orbit. A 100-meter diameter reflector antenna is studied as a flexible body in a near-earth orbit. The dynamics of the body involve nonlinear coupled equations of rotational and generic modes. The generic modes involve the eigenfrequencies of the body. The main disturbances considered on the body are those due to the earth's gravity gradient and vibration modes. A nonlinear control law (the receding horizon concept) is used to stabilize the antenna using linearized version of the equations of motion by retaining a finite number of truncated modes. The nonlinear control law design is compared with linear quadratic regulator controller. Author

A86-39504#
ACTIVE VIBRATION DAMPING EXPERIMENTS AT VPI & SU - OVERVIEW AND RECENT RESULTS
W. L. HALLAUER, JR. and G. R. SKIDMORE (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 437-454. USAF-sponsored research. refs

This paper describes many details of the development of a laboratory for experimental research into the dynamics and active damping of highly flexible structures. Among the topics discussed are: the data acquisition-analysis system; the laboratory structures used for active damping experiments; and the control hardware, including analog circuits, a digital controller, velocity sensors, and force actuators. The active damping techniques that have been implemented are based on velocity feedback. Very recent experimental results are presented for active damping of a two-dimensional structure with the use of five dual (colocated) sensor-actuator pairs. The results consist of frequency response functions measured over 0-10 Hz, encompassing the first thirteen modes of the structure. Author

A86-39505*# State Univ. of New York at Buffalo, Amherst.
VIBRATION CONTROL OF FLEXIBLE BEAMS USING AN ACTIVE HINGE
H. H. CUDNEY, JR., D. J. INMAN (New York, State University, Amherst), and G. C. HORNER (NASA, Langley Research Center, Hampton, VA) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 455-470. refs
(Contract NGT-33-183-802)

The use of an active hinge to attenuate the transverse vibrations of a flexible beam is examined. A slender aluminum beam is suspended vertically, cantilevered at the top. An active hinge is placed at the node of the second vibration mode. The active hinge consists of a torque motor, strain gauge, and tachometer. A control law is implemented using both beam-bending strain and the relative angular velocity measured at this hinge, thereby configuring the hinge to act as an active damper. Results from implementing this control law show little improvement in the first mode damping ratio, 130 percent increase in the second mode damping ratio, and 180 percent increase in the third mode damping ratio. The merits of using a motor with a gearbox are discussed. Author

A86-39506#
ACTIVE STRUCTURAL CONTROL WITH DECENTRALIZED AND COLOCATED CONTROL UNITS
A. ERCOLI FINZI, M. LANZ, and P. MANTEGAZZA (Milano, Politecnico, Milan, Italy) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 487-501. refs

The paper presents an approach to the active control design of large space structures that is based on the adoption of decentralized control units. These control units use colocated sensors and actuators and adopt a control law that generate forces proportional to local motions in order to emulate real structural elements, discrete tuning masses and grounding spring-damper combinations. A modal reduced order model is used to design the control law on the base of the numerical minimization of a multimodel quadratic performance index related to the response and feedback forces following a perturbation of the initial conditions and/or the application of step inputs. It is shown how the use of this type of control units allow the development of an intrinsic 'fail-safe' design. The results obtained with the application of the concepts developed in this paper are demonstrated by their

application to an experiment in which a thin beam, suspended from the ceiling, is controlled by different combinations of the independent analog control units making use of a velocity transducer, an integrator and an electrodynamic actuator. Author

A86-39507#
ACTUATOR FAILURE DETECTION IN THE CONTROL OF DISTRIBUTED SYSTEMS
H. BARUH (Rutgers University, New Brunswick, NJ) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 503-523. refs

A method is presented for the detection of actuator failures in the control of distributed-parameter systems. The method can be used with any control scheme, and is based on identifying the actuators input from the system response by modal analysis. First, the modal excitations are identified. Estimates of the external forces are then synthesized as a linear combination of the modal forces. The identified external forces are compared with the actuator commands to detect failure and isolate the faulty component(s). The effects of actuator failure on the performance of control systems are investigated, as well as factors that affect the reliability of the failure detection, such as measurement noise and observation spillover. A guideline is proposed to locate the actuators in a way to aid the failure detection process. Author

A86-39508*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
MANEUVERING OF FLEXIBLE SPACECRAFT WITH APPLICATION TO SCOLE
L. MEIROVITCH, R. D. QUINN, and M. A. NORRIS (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 525-545.
(Contract NAG1-225)

This paper is concerned with the derivation of the equations of motion for the Spacecraft Control Laboratory Experiment (SCOLE). For future reference, the equations of motion of a similar structure orbiting the earth are also derived. The structure is assumed to undergo large rigid-body maneuvers and small elastic deformations. A perturbation approach is presented where the quantities defining the rigid-body maneuver are assumed to be relatively large, with the elastic deformations and deviations from the rigid-body maneuver being relatively small. The perturbation equations have the form of linear, non-self-adjoint equations with time-dependent coefficients. An active control technique can then be formulated to permit maneuvering of the spacecraft and simultaneously suppressing the elastic vibration. Author

A86-39509*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SLEWING CONTROL EXPERIMENT FOR FLEXIBLE STRUCTURES
J.-N. JUANG, L. G. HORTA (NASA, Langley Research Center, Hampton, VA), and H. H. ROBERTSHAW (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 547-570. refs

A hardware set-up has been developed to study slewing control for flexible structures including a steel beam and a solar panel. The linear optimal terminal control law is used to design active controllers which are implemented in an analog computer. The objective of this experiment is to demonstrate and verify the dynamics and optimal terminal control laws as applied to flexible structures for large angle maneuver. Actuation is provided by an electric motor while sensing is given by strain gages and angle potentiometer. Experimental measurements are compared with analytical predictions in terms of modal parameters of the system stability matrix and sufficient agreement is achieved to validate the theory. Author

A86-39510*# Illinois Univ., Urbana.
SINGLE STEP OPTIMIZATION STRATEGIES FOR CONSTRAINED RETARGETING MANEUVERS
T. A. W. DWYER, III (Illinois, University, Urbana) and M. S. FADALI (Nevada, University, Reno) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 571-583. refs
(Contract NAG1-436; NSF ECS-83-04968)

The present consideration of recent advancements in the nonlinear guidance of spacecraft, using feedback linearization and decoupling to generate exact nominal commands, gives attention to the correction of saturation effects and oscillation prevention in saturated operating regimes. In the case of spacecraft maneuvered by momentum-transfer devices, real time command generation is possible by means of pointwise minimization of the sum of the squares of the norms of the 'next state error' for the equivalent system and the linear system input. It is also possible to track a nominal trajectory, such as a critically damped harmonic oscillator response, by minimizing the square of the norm of the error between the actual and the tracked states. O.C.

A86-39511#
IMPLEMENTATION PROBLEMS ASSOCIATED WITH SIMULTANEOUS MANEUVER AND VIBRATION SUPPRESSION OF FLEXIBLE SPACECRAFT
H. BARUH (Rutgers University, New Brunswick, NJ) and L. M. SILVERBERG (North Carolina State University, Raleigh) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 585-599. refs

Considerations associated with simultaneous large angle maneuver and vibration suppression of flexible spacecraft are discussed. The spacecraft undergoes nonlinear rigid-body motion and linear elastic motion. The associated modal equations of motion reveal three terms coupling the rigid-body motion and the elastic motion. These terms are due to angular accelerations of the body-fixed axes, centrifugal accelerations, and Coriolis effects. It is shown that vibration can be suppressed without distorting the maneuver using either linear optimal controls or natural controls. However, the maneuver will excite the flexible motion. Modal filters can be used to extract the modal coordinates. It is also shown that parameter uncertainties and errors in sensor measurements needed for vibration suppression will not effect the maneuver although the noise in the control forces and moments will distort the maneuver. Author

A86-39569#
ROBUST CONTROL OF A FLEXIBLE NON-SYMMETRICAL SPACECRAFT
J. S.-C. YUAN (Spar Aerospace, Ltd., Toronto, Canada) (CASI, Canadian Conference on Astronautics, 3rd, Ottawa, Canada, Apr. 23, 24, 1985) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, March 1986, p. 62-74. Sponsorship: Department of Supply and Services. refs
(Contract DSS-06ST-36001-3-2484)

This paper presents a method of simultaneous beam-pointing and attitude control of a flexible spacecraft. The latter represents a candidate concept for the next generation of large communications satellites (e.g. MSAT) which contains many flexible structural elements and are highly non-symmetrical in their overall configurations. The dynamic compensator is of the classical proportional-integral type augmented by a Kalman filter. The results demonstrate how an estimator-based compensator could be designed to retain the robustness properties with regard to parametric variation and spillover from unmodelled dynamics. Author

A86-40607*# Houston Univ., Clear Lake, Tex.
A LINEAR QUADRATIC TRACKER FOR CONTROL MOMENT GYRO BASED ATTITUDE CONTROL OF THE SPACE STATION
J. T. KAIDY (Houston, University, Clear Lake; Rockwell International Corp., Houston, TX) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 239-244. refs
(Contract NAS9-16715; NAS9-18000)
(AIAA PAPER 86-1194)

The paper discusses a design for an attitude control system for the Space Station which produces fast response, with minimal overshoot and cross-coupling with the use of Control Moment Gyros (CMG). The rigid body equations of motion are linearized and discretized and a Linear Quadratic Regulator (LQR) design and analysis study is performed. The resulting design is then modified such that integral and differential terms are added to the state equations to enhance response characteristics. Methods for reduction of computation time through channelization are discussed as well as the reduction of initial torque requirements. Author

A86-40769
SIMULTANEOUS PLANT PARAMETER AND STATE ESTIMATION BY A SUCCESSIVE STATES METHOD
S. J. DODDS (North East London Polytechnic, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 452-457. Research supported by the Royal Aircraft Establishment. refs

A method is presented for automatic estimation of the plant matrices (state transition matrix and discrete time drive matrix) together with the state vector of a time invariant linear plant. It is assumed that the number of variables available for measurement is less than the plant order. The method is first illustrated by means of a simple, second order example and then by means of computer simulations of an application to the attitude control of a space satellite containing a flexure mode in the rotational dynamics, the frequency of which is known only approximately prior to launch. Author

A86-40843* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPLINE-BASED RAYLEIGH-RITZ METHODS FOR THE APPROXIMATION OF THE NATURAL MODES OF VIBRATION FOR FLEXIBLE BEAMS WITH TIP BODIES
I. G. ROSEN (NASA, Langley Research Center, Hampton, VA; Southern California, University, Los Angeles) Quarterly of Applied Mathematics (ISSN 0033-569X), vol. 44, April 1986, p. 169-185. Previously announced in STAR as N85-23100. refs
(Contract AF-AFOSR-84-0393; NAS1-17070)

Rayleigh-Ritz methods for the approximation of the natural modes for a class of vibration problems involving flexible beams with tip bodies using subspaces of piecewise polynomial spline functions are developed. An abstract operator-theoretic formulation of the eigenvalue problem is derived and spectral properties investigated. The existing theory for spline-based Rayleigh-Ritz methods applied to elliptic differential operators and the approximation properties of interpolatory splines are used to argue convergence and establish rates of convergence. An example and numerical results are discussed. Author

A86-41739*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MATERIAL DAMPING OF SIMPLE STRUCTURES IN A SIMULATED SPACE ENVIRONMENT
D. L. EDBERG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena; Stanford, University, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 288-296. refs
(Contract AF-AFOSR-82-0062)

The need for accurate, quantitative knowledge of the vibration dissipation of large space structures is explained. The sources of experimental error in vibrational measurements are detailed. A new method for such testing based on the use of a miniature telemetry system is presented, which allows the testing of structures in a simulated space environment consisting of free-fall inside of a vacuum chamber. Theoretical relations are given for the damping ratios of metals and composites. Measured damping ratios for both aluminum and composite beams and plates, and aluminum planar trusses, are presented. Experimental results are used to evaluate the theoretical damping relations. Author

A86-41741*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC CHARACTERISTICS OF STATICALLY DETERMINATE SPACE-TRUSS PLATFORMS
M. S. ANDERSON (NASA, Langley Research Center, Hampton, VA) and N. A. NIMMO (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 723-728) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 303-307. Previously cited in issue 13, p. 1855, Accession no. A85-30401. refs

A86-42855
SINGULAR PERTURBATION METHODS FOR DISCRETE TIME SYSTEMS
E. C. BEKIR (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 86-94. refs

Some problems associated with applications of the singular perturbation method to the two-time scale discretized time systems are addressed. In practice, the small parameter of the fast time system is often implicit or unknown. A redefinition of the two-time scale property is proposed to resolve this and other related problems. Application to optimal regulators, design tradeoffs, and performance evaluation are also discussed. A practical example of a large space structure system is used to demonstrate the design procedure for implementing the singular perturbation techniques. Author

A86-42909
MODELLING AND DESIGN OF NONLINEAR FEEDBACK CONTROL LAW FOR A LARGE SPACE HOOP-COLUMN ANTENNA
P. BOFAH and A. K. CHOUDHURY (Howard University, Washington, DC) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 637-641. refs

The problem of modelling and design of a nonlinear control law for the hoop-column antenna in orbit is presented. A 100-meter diameter reflector antenna is studied as a flexible body in a near-earth equatorial circular orbit. The dynamics of the body involve nonlinear coupled equations of rotational and generic modes. The generic modes involve the eigenfrequencies of the body. The main disturbances considered on the body are those due to the earth's gravity gradient and vibration modes. A nonlinear control law (the receding horizon concept) is used to stabilize the antenna using linearized version of the equations of motion by retaining a finite number of truncated modes. The nonlinear control law design is compared with linear quadratic regulator controller implementation. Author

A86-42921
CONTROL OF SYMMETRIZABLE DISTRIBUTED PARAMETER SYSTEMS
D. J. INMAN (New York, State University, Buffalo) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 729-731. (Contract AF-AFOSR-82-0242)

Attention is given to a subclass of nonself-adjoint distributed parameter systems (NDPSs) described by partial differential equations which are second order in time. This subclass includes those systems which have coefficients that lie in a class of symmetrizable operators. The control problem considered is that of the validity of using a finite dimensional model in designing a control law for such systems. This involves a straightforward application of the results of Gibson (1981) and Sakawa (1984) to a class of symmetrizable systems. A class of NDPSs is indicated that can be controlled by finite dimensional control laws without introducing instabilities into the closed loop system. The results are applicable to large flexible space structures. B.J.

A86-42938*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FAILURE DETECTION AND ACCOMMODATION IN STRUCTURAL DYNAMICS SYSTEMS USING ANALYTIC REDUNDANCY
J. P. WILLIAMS and R. C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 906-910. refs

The concept of analytic redundancy is extended to identify nonzero constant output failures in large spacecraft active control sensors and actuators, using a set of distributed sensors which do not nominally produce equivalent signals but are related through the structural dynamics of the system. The suboptimal technique uses a Sequential Probability Ratio Test on the residual sequence of a Kalman filter based on a modal structure model, to determine failure of a component based on an assumed failure hypothesis. The specific failure is identified and then the Kalman filter gains are reconfigured for the identified remaining working sensor set. Experimental data using an apparatus whose dynamics are representative of a large spacecraft show the nominal filter performance under failed and unfailed conditions. R.R.

A86-42939
INTEGRATION OF STRUCTURES AND CONTROLS - SOME COMPUTATIONAL ISSUES
D. F. MILLER (Wright State University, Dayton, OH), V. B. VENKAYYA, and V. A. TISCHLER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 924-931. refs

This paper discusses issues related to the integration of the structural and control design processes for large scale structural systems. These issues are discussed in the context of vibration suppression for large space structures using linear regulator theory. The controlled system is modeled, via finite element analysis, as a system of linear differential equations in modal space. Attention is focused upon the specification of meaningful weighting matrices for the quadratic performance index, reduced order model selection and control design, and the combined optimization of structural and control designs. Numerical simulations for two and three bay trusses illustrate the concepts presented. Author

A86-42941
VIBRATION CONTROL OF FLEXIBLE STRUCTURES USING MEMBER DAMPERS
N. H. MCCLAMROCH (Michigan, University, Ann Arbor) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 936-939. refs

Mathematical models of electromechanical-damper-controlled flexible-membered structures are developed and used to design simple hierarchical vibration controls. The models account for the dynamic effects of electromechanical interactions, of control force and moment transmission to the structure, and of the structure itself. The hierarchical control developed theoretically is spatially decentralized, and its closed-loop stability is found to depend on the gain matrices. The implications of these findings for the design of actuator vibration controllers for lightly damped structures such as flexible spacecraft are considered, and the need to take actuator dynamics into account is stressed. T.K.

A86-42960
ESTIMATION OF FREQUENCIES OF VIBRATION USING LATTICES
D. M. WIBERG and J. T. GILLIS (Aerospace Corp., Los Angeles, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1157-1162. Research supported by the Aerospace Corp. refs

On-line structural identification by use of lattice-form linear least-square algorithms is discussed. Some background is given concerning lattices and their uses in structural identification. The collapsed form of the lattice (vibration lattice) is compared with the usual lattice using simulated data from the ACOSS II (Active Control of Space Structures) model. Methods for extracting natural frequencies from parameters determined by the lattices are discussed, and the inverse system for multiple inputs and multiple outputs is derived. Problems concerning extending the vibration lattice to the known input case are addressed. It is concluded that the vibration lattice is numerically superior to, and faster converging than, the usual lattice for the case of free vibration with no noise, especially when many sensors are used. C.D.

A86-42965
IDENTIFICATION OF SPACE STATION DYNAMICS
B. SRIDHAR (Lockheed Research Laboratories, Palo Alto, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1264, 1265.

The dynamic parameters of the Space Station (SS) for the early 1990s are identified by applying the maximum likelihood estimation (MLE) method in a finite element model of the SS configuration as chosen by NASA. The amount of computation in the MLE approach is reduced by using the method of successive approximation. The finite element analysis uses 19 modes and the initial operational capability (IOC) shows a 75 KW configuration. Numerical results based on simulated data are presented. B.A.

A86-42989
A NONLINEAR ATTITUDE CONTROL LAW FOR A SATELLITE WITH FLEXIBLE APPENDAGES
S. MONACO (Roma, Universita, Rome, Italy) and S. STORNELLI (Telespazio S.p.A., Rome, Italy) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1654-1659. Research supported by Telespazio S.p.A. refs

The wide-angle attitude-control problem for a satellite with flexible appendages is considered. On the basis of the model specified by the kinematic equations (in the unitary quaternions parametrization) and by the dynamical equations (from the hybrid coordinates approach), a static-state feedback control law is

proposed. The simulations are characterized by the effort of overcoming some obvious problems which arise in the practical implementation of the proposed control law. Author

A86-42995
REDUCED ORDER COMPENSATOR DESIGN FOR AN EXPERIMENTAL LARGE FLEXIBLE STRUCTURE
C. PH. OPDENACKER, E. A. JONCKHEERE, and M. G. SAFONOV (Southern California, University, Los Angeles, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1799-1805. refs
(Contract NSF ECS-82-12479)

A low-order controller is designed for the experimental truss structure described by Major and Simonian (1984). The objective is to achieve good disturbance attenuation while preserving good stability margin and other robustness properties. The method used as a first cut is LQG with frequency-dependent weights and colored noises. Controller reduction is accomplished through the open-loop balancing scheme of Moore (1981), applied to the full-order compensator. A typical result shows that it is possible to obtain a very low-order design which meets the above specification. Author

A86-43003
TRANSFER OF ALIGNMENT AND CALIBRATION OF MULTIPLE SENSORS IN FLEXIBLE SYSTEMS
H. C. SALZWEDEL and K. M. KESSLER (Systems Control Technology, Inc., Palo Alto, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1932-1937. refs

A method for the transfer aligment and calibration of sensors in flexible systems is presented. Flexible systems are represented by high order differential equations and reduced in dimension by model order reduction techniques. Both disturbability of alignment errors by control and disturbance inputs are considered. The reduced order model is decomposed by non-symmetric Riccati decomposition into states that directly and indirectly affect alignment errors. A transfer alignment and calibration filter with control feedthrough is developed and demonstrated for the example of a large flexible aircraft model in turbulence. Author

A86-43005
A MATHEMATICAL FORMULATION OF A LARGE SPACE STRUCTURE CONTROL PROBLEM
A. V. BALAKRISHNAN (California, University, Los Angeles) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1989-1993. refs
(Contract AF-AFOSR-83-0318)

An abstract mathematical formulation is presented of a Large Space Structure Control Problem experiment being conducted by the Space Controls Branch at the NASA Langley Research Center. The physical apparatus consists of a softly supported antenna attached to the Space Shuttle by a flexible beam-like truss. The control objective is to slew the antenna on command within the given accuracy while maintaining stability based on noisy sensor data and limited control authority. The beam motion is modelled by partial differential equations, starting with the equations of motion as derived by Taylor and Balakrishnan (1984). The abstract formulation as a nonlinear wave equation in a Hilbert space is given, and existence and uniqueness theory is addressed. Basic controllability results are reported, and the stabilizability results are given. The time-optimal control problem is briefly considered. C.D.

A86-43208* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A THREE-DIMENSIONAL DYNAMIC ANALYSIS AND LIBRATION STUDY OF A TETHERED SATELLITES SYSTEM
C. C. H. TANG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) and B. C. BARISH (California Institute of Technology, Pasadena) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 109-131. NASA-supported research. refs
(AAS PAPER 85-340)

By a three-dimensional Lagrangian formulation, an exact set of ten coupled nonlinear second-order differential equations has been derived for a system with an extensible tether connecting two end satellites of distributed mass. The effects of tether mass, small orbital eccentricity, central body oblateness, aerodynamic drag force, and solar radiation pressure are also included in the formulation. By linearizing the exact differential equations, the in-plane (orbital plane) differential equations are found to be decoupled from the out-of-plane ones. The characteristic equation of the in-plane differential equations is derived and some associated stability constraints are shown. Author

A86-43213
A MULTIBODY DYNAMICS EQUATION FORMULATION BY MOMENTUM PRINCIPLE
M. TONG (Aerospace Corp., Control Analysis Dept., Los Angeles, CA) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 219-238. refs
(Contract F04701-83-C-0084)
(AAS PAPER 85-391)

Equations of motion are obtained using the momentum principle for an arbitrary collection of N rigid bodies that are interconnected by hinges in a tree configuration. Rotational and translational motions are permitted at the hinges. The derived equations are a set of first order nonlinear differential equations in Hamiltonian form, in that the system states are the generalized coordinates and the generalized momenta of the system. Also presented in this paper are the treatment of the equations of motion with constraints, and the computer implementation of the derived equations for multibody dynamics simulations. Author

A86-43214
ON THE DYNAMICS OF BEAM TYPE STRUCTURAL MEMBERS DURING DEPLOYMENT
A. M. IBRAHIM and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 239-256. refs
(Contract NSERC-G-1547)
(AAS PAPER 85-392)

Using a rather general formulation of the problem representing a large class of space platforms with flexible, extensible members, the paper attempts to study complex interactions between deployment, attitude dynamics and flexural rigidity. The governing nonlinear, nonautonomous and coupled equations of motion are extremely difficult to solve even with the help of a computer, not to mention the cost involved. Effectiveness of the versatile formulation is demonstrated through its application to dynamical situations of practical interest involving beam-type appendages. Response of the hybrid systems is obtained over a range of physical parameters and external disturbances. Both transient as well as postdeployment phases are considered. Results suggest significant influence of flexibility, inertia, deployment time history and orbital parameters on the system stability. The presence of free molecular and solar radiation induced environmental forces may further accentuate this tendency. The study represents a necessary first step towards development of a suitable control strategy. Author

A86-43215
ON MODELING THE DYNAMICS OF LARGE SPACE MANIPULATORS
A. K. MISRA (McGill University, Montreal, Canada) and X. CYRIL IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 257-275. refs
(AAS PAPER 85-393)

A space manipulator composed of N flexible links connected in a chain by pinned joints is considered. Each link is assumed to be a slender rod. At the end of each link a concentrated mass representing the joint (including the servomotor) is attached. The payload is attached at the end of the Nth link. A Lagrangian formulation is carried out using the 4 x 4 homogeneous transformation matrices. Use is made of the fact that the nondimensionalized modal coordinates are small. This makes it possible to study the structural oscillations in a perturbative manner. An example is considered and it is noticed that the position error of the end effector can be significant even though the structural translatory deflections are not large. Author

A86-43217* Howard Univ., Washington, D. C.
THE DEVELOPMENT OF OPTIMAL CONTROL LAWS FOR ORBITING TETHERED PLATFORM SYSTEMS
P. M. BAINUM, S. WOODARD (Howard University, Washington, DC), and J.-N. JUANG (NASA, Langley Research Center, Hampton, VA) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 291-314. Research supported by NASA and Howard University. refs
(AAS PAPER 85-360)

A mathematical model of the open and closed loop in-orbit plane dynamics of a space platform-tethered-subsatellite system is developed. The system consists of a rigid platform from which an (assumed massless) tether is deploying (retrieving) a subsatellite from an attachment point which is, in general, offset from the platform's mass center. A Lagrangian formulation yields equations describing platform pitch, subsatellite tether-line swing, and varying tether length motions. These equations are linearized about the nominal station keeping motion. Control can be provided by both modulation of the tether tension level and by a momentum type platform-mounted device; system controllability depends on the presence of both control inputs. Stability criteria are developed in terms of the control law gains, the platform inertia ratio, and tether offset parameter. Control law gains are obtained based on linear quadratic regulator techniques. Typical transient responses of both the state and required control effort are presented. Author

A86-43219
AN ASYMPTOTIC PERTURBATION METHOD FOR NONLINEAR OPTIMAL CONTROL PROBLEMS
J. L. JUNKINS (Texas A & M University, College Station) and R. C. THOMPSON (Virginia Polytechnic Institute and State University, Blacksburg) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 333-348. refs
(Contract F49620-83-K-0032)
(AAS PAPER 85-364)

A quasi-analytical method is presented for solving nonlinear, open-loop, optimal control problems. The approach combines a simple analytical, straightforward expansion from perturbation methods with powerful numerical algorithms (due to Ward and Van Loan) to solve a series of nonhomogeneous, linear, optimal control problems. In the past, the only recourse for solving such nonlinear problems relied almost exclusively on iterative numerical methods whereas the asymptotic perturbation approach may produce accurate solutions to nonlinear problems without iteration. The nonlinear state and costate equations are derived from the optimal control formulation and expanded in a power series in terms of a small parameter contained either explicitly in the equations or implicitly in the boundary conditions. Each order of the expansion is shown to be governed by a nonhomogeneous, ordinary differential equation. Representing the generally nonintegrable, nonhomogeneous terms by a finite Fourier series, efficient matrix exponential algorithms are then used to solve the system at each order, where the order of the expansion is extended to achieve the appropriate precision. The asymptotic perturbation method is broadly applicable to weakly nonlinear optimal control problems, including higher order systems frequently encountered in aerospace vehicle dynamics and control. A number of numerical examples demonstrating the perturbation approach are included. Author

A86-43220
DYNAMICS AND CONTROL CHARACTERISTICS FOR THE WISP 300 M DIPOLE ANTENNA/SHUTTLE CONFIGURATION
K. W. LIPS, W. B. GRAHAM, F. R. VIGNERON, and D. G. HUNTER (Canadian Department of Communications, Communications Research Centre, Ottawa, Canada) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 349-369. refs
(AAS PAPER 85-365)

The joint Canada/U.S. Waves in Space Plasmas (WISP) program, scheduled for a 1990 launch, calls for two long flexible booms to be deployed from the Shuttle Orbiter to form a dipole antenna of variable lengths up to 300 m tip-to-tip. This paper examines the fundamental character of the response of the configuration to vernier thruster torque and to constant spin rate. It is found, for example, that firing of a single yaw-inducing thruster pulse of longer than 10 s duration will result in excessively large tip deflections. At steady state spin rates larger than 0.25 rpm, centrifugal forces induce excessive tip deflections. As well, a preliminary assessment suggests that antenna deployment and solar-induced heating can contribute significant deflections and require further study. Vibration control is demonstrated using an open-loop Half-Period-Pulsing strategy and an optimal control strategy. The combined effect of large deflections together with a long period associated with the response will likely restrict the degree of maneuverability of the 300 m Shuttle/WISP configuration. Author

A86-43221
STRUCTURAL CONTROL REQUIREMENTS FOR THE 1990S
R. D. AGLER (Martin Marietta Corp., Denver, CO) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 375-384.
(AAS PAPER 85-420)

Design goals and restrictions for future aerospace structural control systems are examined. The retargeting control for the system must rapidly reorient the payload from one target to the next without disturbing the line-of-sight (LOS); a large actuator/isolator between the payload and the aft body is utilized to provide the retargeting torques and forces. Approaches for retargeting control such as polynomial profiles, variable pivot point, and optimal slew algorithms are discussed. The capabilities of the isolation controller which works in combination with the retargeting controller to eliminate the broadband disturbance transmission paths between the aft body and the payload are analyzed. The fine-pointing and alignment control system for improving the LOS response to disturbance inputs is studied. The vibration suppression control system is employed to reduce the amplitude vibration over a broad band, which is necessary to accelerate the transient settling time for the structure. Two procedures for expanding the bandwidth controlled by the vibration suppression system are described. The interrelationships between the subsystems are considered. An example of an aerospace control system is presented. I.F.

A86-43222* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF NOISE ON ERA-IDENTIFIED MODAL PARAMETERS
J.-N. JUANG and R. S. PAPPA (NASA, Langley Research Center, Hampton, VA) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 385-407. refs
(AAS PAPER 85-422)

The basic concept of the Eigensystem Realization Algorithm (ERA) for modal parameter identification and model reduction is extended to minimize the distortion of the identified parameters caused by noise. The mathematical foundation for the properties of accuracy indicators such as the singular values of the data matrix and modal amplitude coherence is provided based on knowledge of the noise characteristics. These indicators quantitatively discriminate noise from system information and are used to reduce the realized system model to a better approximation of the true model. Monte Carlo simulations are included to support the analytical studies.

A86-43224
ROBUST ATTITUDE AND SHAPE CONTROL OF THIRD GENERATION SPACECRAFT
E. J. DAVISON (Toronto, University, Canada) and W. GESING (Honeywell, Ltd., Toronto, Canada) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 431-450. Research supported by the Canadian Department of Communications. refs
(AAS PAPER 85-425)

The problem of finding existence conditions and a robust controller which solve the attitude and shape control problem for large flexible space structures is considered. The basis of the approach taken is to formulate the problem as a robust servomechanism problem and thence to obtain existence conditions and a controller characterization to solve the problem. An application of the results obtained to control a third-generation spacecraft, as modelled by the MSAT configuration, is made. The final controller obtained for MSAT has a distributed control configuration, and appears to be quite successful when applied to both the nominal design MSAT model and an unknown evaluation MSAT model. Author

A86-43772
CONTROL OF DYNAMIC RESPONSE OF A CONTINUUM MODEL OF A LARGE SPACE STRUCTURE
S. N. ATLURI (Georgia Institute of Technology, Atlanta) and P. E. ODONOGHUE Computers and Structures (ISSN 0045-7949), vol. 23, no. 2, 1986, p. 199-209. refs
(Contract AF-AFOSR-84-0020)

The problem of active control of the transient dynamic response of large space structures, modeled as equivalent continua, is investigated here. The effects of initial stresses, in the form of in-plane stress resultants in an equivalent plate model, on the controllability of transverse dynamic response, are studied. A singular solution approach is used to derive a fully coupled set of nodal equations of motion which also include nonproportional passive damping. One approach considers a direct attack on this system of nodal equations. An alternative scheme implements a reduced-order model of coupled ordinary differential equations which are obtained in terms of the amplitudes of the pseudomodes of the nominally undamped system. Optimal control techniques are employed to develop a feedback control law. Algorithms for the efficient solution of the Riccati equation are implemented. Several examples are presented which involve the suppression of vibration of the transient dynamic response of the structure using an arbitrary number of control force actuators. Author

A86-44884*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VIBRATION OF A LARGE SPACE BEAM UNDER GRAVITY EFFECT
C.-F. SHIH, J. C. CHEN, and J. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1213-1216. NASA-supported research. refs

Future space structures will have a low mass density and high flexibility, with ground test dynamic behavior differing significantly from that in zero-G orbit. Attention is presently given to the vibration behavior of a beam deformed by its own weight; the results obtained by the differential equations for both the static and dynamic responses of a large, simply supported beam, which are derived and solved analytically, allow ground test experiment measurements to be used for orbital dynamic characteristics verification efforts. O.C.

A86-45423*# Columbia Univ., New York.
NONLINEAR RESPONSE - A TIME DOMAIN APPROACH
R. VAICAITIS (Columbia University, New York) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs
(Contract NAG1-541)
(AIAA PAPER 86-1934)

The present paper reviews the basic concepts of nonlinear response of panels to surface flow and acoustic pressures, simulation of random processes, time domain solutions and the Monte Carlo Method. Applications of this procedure to the orbit-on-demand space vehicles, acoustic fatigue and composite materials are discussed. Numerical examples are included for a variety of nonlinear problems to illustrate the applicability of this method. Author

A86-46383
QUASI-ANALYTICAL SOLUTIONS FOR THE DYNAMICS OF A CLASS OF TETHERED SATELLITES WITH DANBY'S AERODYNAMICAL DRAG
I. BONZANI and M. G. ZAVATTARO CHIADO PIAT (Torino, Politecnico, Turin, Italy) Celestial Mechanics (ISSN 0008-8714), vol. 37, Dec. 1985, p. 371-385. Research supported by the Ministero della Pubblica Istruzione. refs

An analytic solution, in terms of expansion of a small parameter, for the classical two-body tethered satellite with a specific drag model (Danby, 1962) is obtained. The time of flight as well as the solution regarding the state variable of the system are expressed in terms of quadratures of the anomaly. Author

A86-46455#
ESTIMATION OF DISTRIBUTED PARAMETER SYSTEMS - SOME CLOSED-FORM SOLUTIONS
D. B. SCHAECHTER (Lockheed Missiles and Space Co., Inc., Palo Alto, CA) (Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers, p. 453-458) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 408-412. Research supported by the Lockheed Independent Research and Development Program. Previously cited in issue 22, p. 3318, Accession no. A85-45925. refs

A86-46462*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
PREDICTIVE MOMENTUM MANAGEMENT FOR THE SPACE STATION
P. D. HATIS (Charles Stark Draper Laboratory Inc., Cambridge, MA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 454-461. refs
(Contract NAS9-16023)

Space station control moment gyro momentum management is addressed by posing a deterministic optimization problem with a performance index that includes station external torque loading, gyro control torque demand, and excursions from desired reference attitudes. It is shown that a simple analytic desired attitude solution

exists for all axes with pitch prescription decoupled, but roll and yaw coupled. Continuous gyro desaturation is shown to fit neatly into the scheme. Example results for pitch axis control of the NASA power tower Space Station are shown based on predictive attitude prescription. Control effector loading is shown to be reduced by this method when compared to more conventional momentum management techniques. Author

A86-46463#
TRAVELING WAVE CONTROL FOR LARGE SPACECRAFT STRUCTURES
A. H. VON FLOTOW (MIT, Cambridge, MA) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 152-160) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 462-468. USAF-supported research. Previously cited in issue 13, p. 1854, Accession no. A85-30337. refs

A86-46464*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FUTURE PAYLOAD ISOLATION AND POINTING SYSTEM TECHNOLOGY
R. A. LASKIN and S. W. SIRLIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 469-477. NASA-supported research.

An overview is presented of the technology associated with the precision pointing of future spaceborne science instruments. High-level architectural options for dealing with the precision pointing problem are considered, and a representative NASA mission set for the 1990s is given. Pointing accuracy and stability requirements are extracted from the mission requirements, with the sub-0.1 arcsec stability requirement emerging as the primary driver. The state of the art of current technology is assessed, including an evaluation of gimbal systems, suspension systems, and actuator and sensor component technology. Areas where the technology needs to be pushed to satisfy future requirements are identified, and some promising design options are proposed. C.D.

A86-46470#
ON-OFF ATTITUDE CONTROL OF FLEXIBLE SATELLITES
S. B. SKAAR (Iowa State University of Science and Technology, Ames), L. TANG, and I. YALDA-MOOSHABAD Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 507-510. refs
(Contract NSF MEA-83-18867)

The relationship between postmaneuver elastic energy and switch time selection is studied in the context of a simple satellite model. The control is restricted in that only three switching times can be selected: the duration of the first thrust interval, the time at which a braking interval begins, and the time at which the braking interval ends. The results show that impulse response functions are potentially useful tools for the selection of control switch times in the bang-bang attitude control of linear, elastic, slewing satellites. Experimentally acquired impulse responses may be suitable for this purpose. The adverse effects of actuation error upon postmaneuver elastic energy levels can be reduced if longer control bursts associated with switch times closer to the minimum-time rigid-body solution are favored over shorter bursts near the minimum-fuel solution. C.D.

A86-47088* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VERIFICATION OF LARGE SPACE STRUCTURES USING SCALE MODELLING LAWS
J.-C. CHEN, J. A. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and L. A. DEMSETZ IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 1 . Schenectady, NY, Union College, 1985, p. 31-36. NASA-supported research. refs

The feasibility of testing large space structures in 1-g environment for the purpose of verifying its performance requirement is considered. Because of the difference in test objectives as compared to the conventional structural systems, the scale modelling laws are examined. The investigation is performed on a generic structural element, a space beam. A preliminary conclusion is obtained based on the results. Author

A86-47403#
MODEL REFERENCE ADAPTIVE CONTROL UNDER UNCERTAINTY OF NONLINEAR FLEXIBLE MANIPULATORS
J. M. SKOWRONSKI (Queensland, University, Brisbane, Australia) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 11-18. refs
(AIAA PAPER 86-1976)

The manipulator is modelled as an open chain with n DOF, highly nonlinear characteristics and coupling, with elastic links, subject to uncertain gravity and payload and driven by n actuators collocated with joints. It is made to follow a compatible nonlinear but simple rigid model within prescribed accuracy of convergence and in real time, by the introduced signal adaptive feedback controller and subject to specified adaptive laws. The state for the controller is supplied not by time consuming solving of the hybrid state equations but by a much simpler observer integrable in closed form, allowing the control to be implemented by small on-board computer. Author

A86-47411#
CONCEPTUAL DESIGN OF POINTING CONTROL SYSTEMS FOR SPACE STATION GIMBALLED PAYLOADS
R. O. HUGHES (General Electric Co., Space Div., Philadelphia, PA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 78-87. refs
(AIAA PAPER 86-1986)

A conceptual design of the control system for Payload Pointing Systems (PPS) is developed using classic Proportional-Integral-Derivative (PID) techniques. The major source of system pointing error is due to the disturbance-rich environment of the Space Station in the form of gimbal baseplate motions. These baseplate vibrations are characterized using Fast Fourier Transform (FFT) techniques. Both time domain and frequency domain dynamic models are developed to assess control system performance. Three basic methods exist for the improvement of PPS pointing performance: increase control system bandwidth, add Image Motion Compensation, and/or reduce (or change) the baseplate disturbance environment. Author

A86-47412*# Illinois Univ., Urbana.
VARIABLE STRUCTURE CONTROL OF SPACECRAFT REORIENTATION MANEUVERS
H. SIRA-RAMIREZ and T. A. W. DWYER, III (Illinois, University, Urbana) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 88-96. refs
(Contract N00014-84-C-0149; NAG1-436; NSF ECS-85-16445)
(AIAA PAPER 86-1987)

A Variable Structure Control (VSC) approach is presented for multi-axial spacecraft reorientation maneuvers. A nonlinear sliding surface is proposed which results in an asymptotically stable, ideal linear sliding motion of Cayley-Rodriques attitude parameters. By imposing a desired equivalent dynamics on the attitude parameters, the approach is devoid of optimal control considerations. The single axis case provides a design scheme for the multiple axes design problem. Illustrative examples are presented. Author

A86-47414*# Control Research Corp., Lexington, Mass.
RAPID TORQUE-LIMITED LINE-OF-SIGHT POINTING OF SCOLE (SPACECRAFT CONTROL LABORATORY EXPERIMENT) CONFIGURATION
J. G. LIN (Control Research Corp., Lexington, MA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 106-114. refs
(Contract NAG1-386)
(AIAA PAPER 86-1991)

The design concept of a control for rapid torque-limited slewing of a rigid-mast version of the NASA SCOLE configuration is presented and demonstrated by means of numerical simulation. The time-optimal control problem for the system is decomposed into separate single-axis problems, expanding analytically the implicit nonlinear transcendental expression for the SCOLE line-of-sight error, and the final Euler attitude angles and slew angles are determined. The simulation results are presented in tables and graphs, and it is found that bang-bang or bang-pause-bang slew maneuvers with control moment applied to the Shuttle and control force applied to the reflector, and with a 5-deg/s slew-rate limit, produce the best pointing accuracy and the shortest slew times, although the specified line-of-sight error of 0.02 deg cannot be achieved using such open-loop single-axis maneuvers. T.K.

A86-47415*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
MANEUVER AND VIBRATION CONTROL OF SCOLE
R. D. QUINN and L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 115-129. refs
(Contract NAG1-225)
(AIAA PAPER 86-1993)

This paper is concerned with the simultaneous maneuver and vibration control of the Spacecraft Control Laboratory Experiment (SCOLE). Summaries of the derivation of the equations of motion and of a perturbation method permitting a maneuver strategy independent of the vibration control are presented. Some of the problems encountered in dynamical modeling of a flexible spacecraft in an earth-based laboratory are high-lighted and solved. Numerical results demonstrating rotational maneuvers of the SCOLE model are included. Author

A86-47430#
MOMENTUM MANAGEMENT CONCEPTS FOR A SPACE STATION
H. H. WOO, H. D. MORGAN, and E. T. FALANGAS (Rockwell International Corp., Downey, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 277-286. Research sponsored by Rockwell International Corp. refs
(AIAA PAPER 86-2047)

A momentum management concept applicable to the dual-keel configuration of the Space Station is presented. The system dynamic equation is given, and the dominant environmental disturbances, gravity-gradient torque and aerodynamic torques, are discussed. Induced dynamic disturbances, including both unscheduled and scheduled disturbances as well as disturbances that exceed control moment gyro (CMG) capability are specified, including their magnitude and direction. The sizing of CMG momentum storage is briefly addressed, as are unscheduled and scheduled momentum requirements. The integrated momentum management concept for transition and steady-state operation is then identified and developed for keeping torque equilibrium attitude maneuvers to a minimum in order to provide a stable environment for experiments. For more dynamic conditions, a logic is developed for handling the situation responsively while maintaining the momentum within bounds. C.D.

A86-47431*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN EIGENSYSTEM REALIZATION ALGORITHM IN FREQUENCY DOMAIN FOR MODAL PARAMETER IDENTIFICATION
J.-N. JUANG and H. SUZUKI (NASA, Langley Research Center, Hampton, VA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 287-295. refs
(AIAA PAPER 86-2048)

This paper demonstrates the close conceptual relationships between time domain and frequency domain approaches to identification of modal parameters for linear systems. A frequency domain eigensystem realization algorithm, via transfer functions, is developed using a known procedure formulated for a time domain eigensystem realization algorithm, via free decay measurement data. An important feature is the capability of windowing to concentrate analysis on the frequency range of interest. The procedure of overlap averaging is used to produce smoother spectra to reduce the effect of noise on identified modal parameters. Examples from simulation and experiments are given to illustrate the validity of formulations derived in the paper. Author

A86-47432#
A SQUARE ROOT METHOD FOR THE IDENTIFICATION OF LARGE SPACE STRUCTURES
T. WILLIAMS (Kingston Polytechnic, Kingston upon Thames, England) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 296-302. SERC-supported research. refs
(AIAA PAPER 86-2049)

A new algorithm for identifying the dynamics of a flexible large space structure from in-flight vibration measurements is presented. The novel aspect of this method is that it directly identifies a square root of the mass matrix rather than the matrix itself, resulting in all the well-documented accuracy improvements typical of algorithms based on matrix factorization techniques. The properties of this algorithm are analyzed in detail and illustrated with examples. C.D.

A86-47433#
DESIGN OF DYNAMIC OUTPUT FEEDBACK CONTROLLERS WITH PARAMETER VARIATION INSENSITIVITY
Z.-Q. GU and R. W. LONGMAN (Columbia University, New York) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 303-313. refs
(AIAA PAPER 86-2050)

Two fundamental contributions of modern control theory are the Linear-Quadratic and pole placement design methods. Since it is often impractical to measure the full state vector, both these methods can suffer from controller dimension problems and from robustness problems when parameter uncertainties are present. These difficulties are addressed here for both approaches. Necessary conditions for optimality are derived, and a steepest descent algorithm is generated, to design fixed-order controllers that are optimal with respect to a quadratic performance index which includes quadratic penalties on the performance sensitivity with respect to parameter variation. A second algorithm is developed to accomplish pole placement with fixed order controllers where the freedom remaining after pole placement is used to minimize the eigenvalue sensitivities. Both steepest descent algorithms are shown to be effective design methods in worked examples. Author

A86-47434*# California Univ., Los Angeles.
MODIFIED LTR ROBUST CONTROL FOR FLEXIBLE STRUCTURES
P. A. BLELLOCH and D. L. MINGORI (California, University, Los Angeles) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 314-318. refs
(Contract NAS7-918)
(AIAA PAPER 86-2051)

A procedure is developed for dealing with performance and robustness issues in the design of multi-input multi-output compensators for lightly damped flexible structures. The procedure is based upon representing errors in the plant design model as structured uncertainties, and applying a modified version of the Loop Transfer Recovery (LTR) design method. Real parameter errors, such as frequency errors, damping errors or modal displacement errors can be treated. The approach involves adjusting the cost function in the regulator problem and the process noise model in the estimator problem in a particular manner which reflects the assumed structure of the modeling errors. Numerical examples dealing with the control of a large flexible space antenna with uncertain frequencies demonstrate a considerable improvement over standard LTR methods. Convenient design parameters can be varied until a satisfactory compromise is achieved between performance and robustness. Author

A86-47435#
ROBUST REDUCED-ORDER CONTROL OF FLEXIBLE STRUCTURES USING THE OPTIMAL PROJECTION/MAXIMUM ENTROPY DESIGN METHODOLOGY
A. GRUZEN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) and W. E. VANDER VELDE (MIT, Cambridge, MA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 319-327. refs
(Contract F04611-85-K-0051)
(AIAA PAPER 86-2052)

This paper describes the capabilities of the Optimal Projection/Maximum Entropy (OP/ME) design methodology for the development of an active vibration damper. A full-state LQG compensator was generated to provide a reference design for both robustification and order reduction studies. The compensator is shown to be sensitive to presumed variations in plant parameters through application to a set of perturbed plants. The LQG compensator displays degraded performance over the set of plants and in some cases results in closed-loop instability. Subsequently, reduced-order compensators were designed, illustrating the capabilities of the optimal projection design approach. The maximum entropy methodology is envoked to robustify the compensators, and the resulting designs are shown to be tolerant of all postulated modeling errors. Author

A86-47436#
A PARAMETRIC EXAMINATION OF THE STABILITY ROBUSTNESS CHARACTERISTICS OF TWO DECOUPLED CONTROLLERS DESIGNED FOR LARGE SPACE STRUCTURE CONTROL
J. W. HESS (U.S. Air Force Academy, Colorado Springs, CO) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 328-337. refs
(AIAA PAPER 86-2053)

The system model for a large space structure is developed, and some of the destabilizing spillovers are presented. Two controllers are designed, one with an observer and one which uses direct output feedback, which eliminate the destabilizing spillover by decoupling their several reduced order sub-controllers. An error model is then developed which uses the structure of the model to determine the potentially most destabilizing directions. Reasonable errors are then examined to determine which lie in the most critical directions. Armed with this reasonable set of potentially destabilizing errors, perturbed models are then determined. The decoupled control design for the nominal case is then applied to the perturbed models and the system eigenvalues are examined for instabilities. The results indicate that the two control designs have different robustness characteristics, but one design is not necessarily more robust than the other. Finally, all of the information gleaned in determining the robustness of the two designs is used to design a more robust controller. Author

A86-47451#
MODEL REDUCTION AND MODAL ASSIGNMENT IN DECOUPLED CONTROL
R. A. CALICO (USAF, Institute of Technology, Wright-Patterson, AFB, OH) and D. VARHOLA IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 461-468. refs
(AIAA PAPER 86-2137)

The control of both the CSDL I and II spacecraft models is considered. Decoupled control using two or more subcontrollers was implemented. Model truncation effects were considered by comparing results for internally balanced models with those for models formed by truncating higher frequency modes. The effect of modal assignments to the various sub controllers in the decoupled design is also shown. Author

A86-47452*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ATTITUDE CONTROL SYSTEM SYNTHESIS FOR THE HOOP/COLUMN ANTENNA USING THE LQG/LTR METHOD
N. SUNDARARAJAN, S. M. JOSHI, and E. S. ARMSTRONG (NASA, Langley Research Center, Hampton, VA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 469-478. refs
(AIAA PAPER 86-2139)

This paper investigates the application of the linear-quadratic-Gaussian (LQG)/loop transfer recovery (LTR) method to the problem of synthesizing a fine-pointing control system for a large flexible space anenna. The study is based on an antenna, which consists of three rigid-body rotational modes and the first ten elastic modes. A robust compensator design for achieving the required pointing performance in the presence of modeling uncertainties is obtained using the LQG/LTR method. For the Hoop/Column antenna, a satisfactory controller design meeting a desired bandwidth of .1 rad/sec and ensuring stability with unmodelled high frequency modes is obtained using only a collocated pair of 3-axis attitude sensors and torque actuators. This study also indicates that to achieve the desired performance bandwidth of 0.1 rad/sec. and to ensure stability in the presence of higher frequency elastic modes, the design model should include at least the first three flexible modes together with the rigid body modes. Author

A86-47454*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL EFFECTIVENESS CHARACTERIZATION FOR STATE ESTIMATION AND CONTROL ON A HIGHLY FLEXIBLE GRID
R. C. MONTGOMERY, J. P. WILLIAMS, T. L. LAZARUS, and P. E. NELSON (NASA, Langley Research Center, Hampton, VA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 488-492. refs
(AIAA PAPER 86-2142)

Control effectiveness tests of reaction wheel actuators on a highly flexible grid are reported herein. Analytic determination of actuator control effectiveness is accomplished with finite element modelling. Experimental determination is done with two algorithms. The first is an equation error parameter identification scheme which estimates the control coefficients of the second order difference equation model of each vibration mode. The second is a least square error algorithm using the same model. For both methods there is a lack of agreement with analytic prediction. Author

A86-47471#
CONTROL-MOTIVATED DYNAMIC TAILORING OF TRUSS-WORK STRUCTURES
A. H. VON FLOTOW (MIT, Cambridge, MA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 622-628. USAF-supported research. refs
(AIAA PAPER 86-2190)

This paper reviews past approaches to control-motivated dynamic tailoring and their impact upon the problem of active control of structural dynamics. The costs and benefits of passive damping augmentation are estimated; the conclusion is drawn that the optimum structural design will be in the 'left-half s-plane'. New results on dynamic tailoring of truss-work structures are presented. The proposed techniques exploit inherent characteristics of such structures to reduce the mass penalty associated with passive damping augmentation. Author

A86-47472#
DYNAMICS AND CONTROL OF SLEW MANEUVER OF LARGE FLEXIBLE SPACECRAFT
Y. P. KAKAD (North Carolina, University, Charlotte) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 629-634. refs
(AIAA PAPER 86-2192)

In this paper, the dynamics and control of slewing maneuvers of a large flexible spacecraft namely, NASA-Spacecraft Control Laboratory Experiment (SCOLE) test article are studied. The dynamical equations obtained for slewing maneuvers are highly nonlinear and coupled. The maneuver is expressed in terms of four Euler parameters and is specified as the angular displacement about an arbitrary axis. The slew maneuver control problem is developed in terms of rigid-body slewing and suppression of two elastic modes is analyzed using the method of nonlinear decoupling. Author

A86-47473#
MANEUVERING OF FLEXIBLE SPACECRAFT
H. OZ (Ohio State University, Columbus) and O. MOSTAFA IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 635-643. refs
(AIAA PAPER 86-2193)

Variable Structure Control Systems (VSCS) are a class of nonlinear systems which change the structure of the controls when a set of prescribed hypersurfaces are reached in the phase space. The VSCS theory has, desirable insensitivity properties under parameter uncertainties, nonlinear effects, and external disturbances. The theory represents a real-time implementable approach to control in contrast to algorithmic approaches, and therefore eliminates the computational burden. However, a practical problem in the implementation of VSC theory is the possibility of chatter about hypersurfaces known as 'sliding regimes'. This paper extends the previous applications by the authors of VSCS theory to maneuvering of flexible spacecraft. Three methods of chatter alleviation are introduced. Specifically, the methods are: a boundary layer approach, asymptotic reaching of sliding regimes, and digital input prefiltering. Illustrative examples are given for a single-axis rest-to-rest maneuver of a flexible spacecraft, demonstrating the success of the three methods in alleviating the chatter phenomenon. In association, robustness to parameter uncertainties is also illustrated. Author

A86-47474#
DYNAMICS OF A DEFORMABLE POINTING SPACECRAFT BY KANE'S METHOD, AND TELESCOPE'S IMAGE-STABILITY EVALUATION
H. B. HABLANI (Rockwell International Corp., Satellite Systems Div., Seal Beach, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 644-656. refs
(AIAA PAPER 86-2194)

This paper has a twofold objective. First it shows a novel way of applying Kane's technique to formulate dynamics of a spacecraft with a hinged elastic continuum. This approach is then employed to develop motion equations of a generic four-body deformable spacecraft with a telescope and a solar array. The approach in this paper is different from the previous efforts in that (1) a clear separation between discrete and deformational variables is maintained, (2) the discretized equations are reduced to their simplest, minimum dimension form, and (3) the deformational field is discretized by using constrained modes. These differences bring in an otherwise unattainable lucidity in the analysis. The second part of the paper introduces and formulates a new concept called Clutter Leakage Metric, which evaluates image stability of a precision pointing telescope. When a telescope is amidst severe structural vibration of a neighboring articulated body, the telescope may yield cluttered image of a target. To minimize this clutter, electrooptic signals from successive frames are subtracted. Some clutter may still leak into the final image, which then can be measured by the proposed metrics. The metrics involve Fourier spectrum of pointing error, an aspect scantly addressed in the established definition of pointing stability. Author

A86-47478#
MULTI-CRITERION APPROACHES TO OPTIMIZATION OF LINEAR REGULATORS
D. W. REW (Virginia Polytechnic Institute and State University, Blacksburg) and J. L. JUNKINS (Texas A & M University, College Station) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 681-690. refs
(AIAA PAPER 86-2198)

The problem of designing structural control systems is addressed, considering multiple design objectives: state error energy, control energy, and stability robustness. The relationships among the selected design objectives is investigated by solving multiple objective optimization problems, which require parameterizations of feedback gain matrices directly or indirectly. Considered are three types of state feedback design algorithms, including a new one developed in this study: (1) generalized LQR design, (2) modified LQR design based on Lyapunov equation and (3) feedback design using Sylvester's equation. The results of these design schemes are compared by generating trade-off surfaces of the multiple performance objectives. A nonlinear programming method based upon minimum norm correction strategy is utilized in conjunction with a homotopy technique. The nonlinear programming algorithm is found to be very reliable. The paper offers a new approach to multidimensional tuning of each feedback design. Author

A86-47510#
EMULATING STRUCTURAL MOTION BY ARRAY PROCESSORS
E. K. PARSONS and P. J. RESHATOFF (Lockheed Research Laboratories, Palo Alto, CA) AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 10 p. refs
(AIAA PAPER 86-1988)

This paper describes the use of an array processor to simulate the motion of flexible structures in real time. The array processors is fast enough to emulate hundreds of modes less than 20 Hz, or a single mode up to 2.5 KHz. This method makes it possible to design and test real control hardware when the real flexible system

is unavailable or too fragile. For example, this technique can benefit optical systems whose performance critically depends upon flexibility. As an illustration, the paper describes the emulation of a steering mirror with four bending modes, the two highest at 950 Hz. The main result is the demonstrated ability to isolate errors in either the dynamic model or the control hardware. Sampling rate and proper smoothing of the outputs of the D/A convertors limit the use of this method. To address these problems, special techniques are presented for programming the AP and carrying out the emulation. Author

A86-47515#
ISSUES OF ORDER REDUCTION IN ACTIVE CONTROL SYSTEM DESIGN
C. O. PARRY and V. B. VENKAYYA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 8 p. refs
(AIAA PAPER 86-2138)

Vibration suppression and shape control of large space structures through the application of linear optimal control theory is addressed in this paper. Specifically, a new method of obtaining reduced order models for large structural systems using LQG synthesis techniques is investigated and compared to some existing model reduction methods. Results are presented for the control of a two-dimensional truss structure using the reduced-order control system. Author

A86-47518#
OPTIMUM DETUMBLING OF SPACE PLATFORMS VIA A DYNAMIC PROGRAMMING ALGORITHM
R. G. MELTON (Pennsylvania State University, University Park), D. S. RUBENSTEIN, and H. L. FISHER AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 9 p. Research supported by Pennsylvania State University. refs
(AIAA PAPER 86-2154)

A method for determining the optimum detumbling control for a space platform is described which uses internal motions to dissipate kinetic energy, thereby converting the tumble into a simple spin about the major inertia axis. Dynamic programming to automatically generate embedded solutions makes optimum closed-loop control possible. A moveable mass controller is employed. R.R.

A86-47925#
ROBUST MULTIVARIABLE CONTROL OF LARGE SPACE STRUCTURES USING POSITIVITY
G. L. SLATER (Cincinnati, University, OH) and M. D. MCLAREN IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 250-259. refs
(AIAA PAPER 86-2125)

This paper examines the robust, multivariable control of large space structures by controllers designed on a reduced-order model using positivity concepts. Controllers are designed using the DRAPER I and DRAPER II structures. Three different controller methodologies are compared: the familiar multivariable control, individual mode control, and individual sensor control. Controller robustness is measured qualitatively from the plots of the minimum singular value of the return difference matrix as a function of the frequency. All controllers, when designed to give the same total average control cost, have a very similar line-of-sight (LOS) response. All controlled systems have guaranteed asymptotic stability even in the presence of actuator and/or sensor failures. Author

A86-47940*# California Univ., Los Angeles.
NUTATIONAL STABILITY OF A SPINNING SPACECRAFT WITH INTERNAL MASS MOTION AND AXIAL THRUST
D. L. MINGORI (California, University, Los Angeles) and Y. YAM (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 367-375. Research supported by the Aerospace Corp. refs
(AIAA PAPER 86-2271)

Stability conditions are developed for a spinning spacecraft with internal mass motion and axial thrust. The results show that rapid cone angle growth is possible if the thrust magnitude is sufficiently large and the moving mass is aft of the system mass center. The instability does not rely on internal or external dissipation. Author

A86-47942#
FREQUENCIES OF LONGITUDINAL OSCILLATIONS OF TETHERED SATELLITE SYSTEMS
A. K. MISRA (McGill University, Montreal, Canada) and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 386-393. refs
(Contract NSERC-A-0967; NSERC-A-2181)
(AIAA PAPER 86-2274)

Longitudinal vibrations of tethered satellite systems are investigated taking into account the role played by the undeployed part of the tether wrapped around the reel. Three cases are considered: the 'no slip' case, when the friction is sufficient to prevent any motion of the wrapped tether; the 'total slip' case, when there is no friction at all and the entire wrapped portion of the tether is free to move; and the 'partial slip' case, when a part of the undeployed tether has extensional oscillations. An analytical solution is presented for the first case, while Rayleigh-Ritz solutions are obtained for the latter two cases. The variation of the frequencies with the system parameters are studied. It is noted that even for moderate friction the frequencies of oscillation in the 'partial slip' case are quite close to those in the 'no slip' case, for which an analytical solution is available. Author

A86-47955#
SOME CONSIDERATIONS OF ACTUATOR DYNAMICS IN THE ATTITUDE CONTROL OF A FLEXIBLE BEAM
K. C. HOWELL and M. J. BAXTER (Purdue University, West Lafayette, IN) AIAA and AAS, Astrodynamics Conference, Williamsburg, VA, Aug. 18-20, 1986. 25 p. refs
(Contract F49620-82-C-0035)
(AIAA PAPER 86-2124)

In the control system design for large, flexible structures, it is usually assumed that any actuating and sensing devices are of infinite bandwidth, and their dynamic characteristics are not included as part of the system model. Actual sensors and actuators do not respond ideally and different types of devices have different dynamics. This study considers the effects of some finite actuator dynamics in the model of a flexible beam in earth orbit. From some initial attitude disturbance, the system is to be returned to its nominal state using a prescribed set of actuators along the beam. The results of including actuator dynamics are observed in the effects on the actuator placement design and dynamic response in simulation. Initially, a quadratic cost decomposition algorithm is used to determine actuator effectiveness which in turn determines the most effective actuator locations among a finite number of positions available. Controlled simulations are used to study the system response with different linear actuator models. Finally, simulations are also done with a controller which utilizes on/off thrusters and which includes linear actuator dynamics. Author

A86-49094*# Purdue Univ., West Lafayette, Ind.
INTEGRATED STRUCTURE/CONTROL DESIGN - PRESENT METHODOLOGY AND FUTURE OPPORTUNITIES
T. A. WEISSHAAR (Purdue University, West Lafayette, IN), J. R. NEWSOM (NASA, Langley Research Center, Hampton, VA), T. A. ZEILER, and M. G. GILBERT (PRC Kentron, Inc., Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2 . New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1119-1128. refs

Attention is given to current methodology applied to the integration of the optimal design process for structures and controls. Multilevel linear decomposition techniques proved to be most effective in organizing the computational efforts necessary for ISCD (integrated structures and control design) tasks. With the development of large orbiting space structures and actively controlled, high performance aircraft, there will be more situations in which this concept can be applied. K.K.

N86-22631# MATRA Espace, Paris-Velizy (France). Espace Produits et Technologie.
KEY DESIGN PARAMETERS FOR A VERY LOW GRAVITY IN-ORBIT FACILITY Final Report
J. C. AMIEUX, C. FOURNIER, R. STRITTMATTER (Dornier-Werke GmbH, Friedrichshafen, West Germany), M. BAIER (Dornier-Werke GmbH, Friedrichshafen, West Germany), D. SCHMITT (ONERA, Paris, France), and J. MERLET (Intespace) Paris ESA Apr. 1985 372 p refs
(Contract ESTEC-5292/82-NL-PP(SC))
(MATRA-EPT/DT/VT068/098; ESA-CR(P)-2144) Avail: NTIS HC A16/MF A01

Vibration generation and propagation in orbital platforms, including Spacelab and EURECA, were analyzed. Attitude and orbit control subsystem vibration generators; vibrations induced by thermal control subsystems; measurement techniques and experimental aspects for a microgravity environment; vibration induced by microgravity-oriented payloads; and vibration reduction techniques were studied. Dynamic synthesis of a microgravity platform is discussed. Author (ESA)

N86-22997*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL AND ANALYTICAL GENERIC SPACE STATION DYNAMIC MODELS
W. K. BELVIN and H. H. EDIGHOFFER (Edighoffer, Inc.) Mar. 1986 90 p refs
(NASA-TM-87696; NAS 1.15:87696) Avail: NTIS HC A05/MF A01 CSCL 20K

A dynamic model used for verification of analytical and experimental methods is documented. The model consists of five substructures to simulate the multibody, low frequency nature of large space structures. Design considerations which led to a fundamental vibration frequency of less than one Hz are described. Finite element analysis used to predict the vibration modes and frequencies of the experimental model is presented. In addition, modeling of cable suspension effects using prestressed vibration analysis is described. Details of the expermental and analytical models are included to permit replication of the study. Results of the modal vibration tests and analysis are presented in a separate document. Author

N86-23343*# Scientific Systems, Inc., Cambridge, Mass.
FAULT-TOLERANT CONTROL OF LARGE SPACE STRUCTURES USING THE STABLE FACTORIZATION APPROACH Final Report
H. C. RAZAVI, R. K. MEHRA, and M. VIDYASAGAR (Waterloo Univ., Ontario) Washington NASA Mar. 1986 38 p refs
(Contract NAS1-17946)
(NASA-CR-3964; NAS 1.26:3964; SSI-1103) Avail: NTIS HC A03/MF A01 CSCL 09B

Large space structures are characterized by the following features: they are in general infinite-dimensional systems, and have large numbers of undamped or lightly damped poles. Any attempt to apply linear control theory to large space structures must therefore take into account these features. Phase I consisted of an attempt to apply the recently developed Stable Factorization (SF) design philosophy to problems of large space structures, with particular attention to the aspects of robustness and fault tolerance. The final report on the Phase I effort consists of four sections, each devoted to one task. The first three sections report theoretical results, while the last consists of a design example. Significant results were obtained in all four tasks of the project. More specifically, an innovative approach to order reduction was obtained, stabilizing controller structures for plants with an infinite number of unstable poles were determined under some conditions, conditions for simultaneous stabilizability of an infinite number of plants were explored, and a fault tolerance controller design that stabilizes a flexible structure model was obtained which is robust against one failure condition. Author

N86-23629*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
ANALYTICAL INVESTIGATION OF THE DYNAMICS OF TETHERED CONSTELLATIONS IN EARTH ORBIT, PHASE 2 Quarterly Report, 22 Sep. - 21 Dec. 1985
E. LORENZINI, D. A. ARNOLD, M. D. GROSSI, and G. E. GULLAHORN Feb. 1986 53 p
(Contract NAS8-36606)
(NASA-CR-178754; NAS 1.26:178754; QR-3) Avail: NTIS HC A04/MF A01 CSCL 22A

The development of a two dimensional analytical model that describes the dynamics of an n-mass vertical tethered system is reported. Two different approaches are described: in the first one the control quantities are the independent variables while in the second one the Cartesian coordinates of each mass expressed in the orbiting reference frame are the independent variables. The latter model was used in the 3-mass version to simulate the dynamics of the tethered system in applications involving the displacement of the middle mass along the tether. In particular, issues related to reproducing predetermined acceleration profiles and g-tuning are reported. Author

N86-24717# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
THE DETUMBLING OF AN AXIALLY SYMMETRIC SATELLITE WITH AN ORBITAL MANEUVERING VEHICLE BY NONLINEAR FEEDBACK CONTROL M.S. Thesis
K. R. FLEMING 13 Dec. 1985 61 p refs
(AD-A163989; AFIT/GA/AA/85D-5) Avail: NTIS HC A04/MF A01 CSCL 22B

The problem of detumbling a freely spinning and precessing axisymmetric satellite is considered. Detumbling is achieved with another axisymmetric orbital maneuvering vehicle (OMV) joined to the target satellite with a universal joint. The joint provides two rotational degrees of freedom and is translated across the surface of the OMV during the detumbling process. The target satellite and the OMV with its three momentum wheels are modelled as a five body system using Eulerian-based equations of motion developed by Hooker and Margulies. A Liapunov technique is applied to derive a nonlinear feedback control law which drives the system asymptotically to a final spin-stabilized state. State and control histories are presented and indicate that the detumbling process is benign. Constraint force and moment loads at the connection between the OMV and target satellites are also presented, and indicate that no extreme loads are encountered during the despinning and detumbling process. Author (GRA)

N86-24739# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
THE EFFECT OF ENERGY DISSIPATION DUE TO FRICTION AT THE JOINT OF A SIMPLE BEAM STRUCTURE M.S. Thesis
R. P. DONNELLY, JR. Dec. 1985 81 p refs
(AD-A163975; AFIT/GAE/AA/85D-5) Avail: NTIS HC A05/MF A01 CSCL 22B

The Strategic Defense Initiative has generated new interest in the development of more stable space structures. This interest has increased the need for more detailed knowledge of the behavior

of engineering structures under dynamic loading. Interests lie in decreasing the amount of vibration by both passively and actively damping the structure. A means exists to passively damp structures by friction damping resulting from relative slip between joint interfaces. It may be feasible to increase the damping in a structure by allowing more friction damping than is normal and thereby controlling the vibration response. This thesis incorporates friction damping in a one-dimensional model. Finite element techniques are used to accomplish the numerical analysis. A clamped-clamped beam is used as the physical model. The mid-point of the two element beam is allowed to slip in rotation, but not in translation. Because the one-dimensional program cannot handle rotations at continuous nodes, the beam is modeled by symmetry about the joint and a cantilever beam with an applied end moment is studied. Results for the response of a beam in vibration are presented showing displacement of the joint, relative rotation at the joint, and relative angular velocity at the joint; all versus time. Various clamping pressures and initial loads are explored. Diagrams of the beam shape versus time show the shape the beam takes on when slip occurs at the joint. GRA

N86-24740# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MOVING-BANK MULTIPLE MODEL ADAPTIVE ALGORITHMS APPLIED TO FLEXIBLE SPACECRAFT CONTROL M.S. Thesis
P. G. FILIOS Dec. 1985 182 p refs
(AD-A164016; AFIT/GE/ENG/85D-14) Avail: NTIS HC A09/MF A01 CSCL 22B

Critical to the performance of the moving-bank multiple model adaptive estimator is the decision logic used to determine which elemental filters are implemented in the bank, and when to change this decision. The decision logics discussed focus on three situations: initial acquisition of the unknown parameter values through reducing bank discretization; tracking the unknown parameter values through bank movement; and reacquisition of the unknown parameters following a large jump change in their values through expanding bank discretization. Ambiguity function analysis is used to predict performance in these situations. The system to be controlled is a simplified model of a large scale space structure. Its equations of motion are developed and placed in state space form, the states being the positions and velocities of the rigid body mode and the second and fourth bending modes. The state space matrices describing the system are computed based on nominal values for all physical parameters with the exception of the mass density of the structure arms and their modulus of elasticity. GRA

N86-25019*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MATHEMATICAL CORRELATION OF MODAL PARAMETER IDENTIFICATION METHODS VIA SYSTEM REALIZATION THEORY
J. N. JUANG Apr. 1986 47 p refs
(NASA-TM-87720; NAS 1.15:87720) Avail: NTIS HC A03/MF A01 CSCL 20K

A unified approach is introduced using system realization theory to derive and correlate modal parameter identification methods for flexible structures. Several different time-domain and frequency-domain methods are analyzed and treated. A basic mathematical foundation is presented which provides insight into the field of modal parameter identification for comparison and evaluation. The relation among various existing methods is established and discussed. This report serves as a starting point to stimulate additional research towards the unification of the many possible approaches for modal parameter identification. Author

N86-25402# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MODAL ASSIGNMENT EFFECTS ON DECENTRALIZED CONTROL OF A LARGE SPACE STRUCTURE M.S. Thesis
J. B. SUMNER Dec. 1985 158 p refs
(AD-A163977; AFIT/GA/AA/85D-9) Avail: NTIS HC A08/MF A01 CSCL 22B

The more modes a designer can keep in the model of the system/space structure, the less inaccurate it will be. But the computational burden to an online computer, functioning as the controller, grows also. The thrust of this thesis is to implement time response output for the nontrivial model and investigate the effect on time response of certain modal assignments by fixed groups to any of the three controllers with another fixed group assigned as residuals. The inclusion of residuals provides in a limited sense a truth model for the analysis of stability and performance. There may be significant differences in time response caused by the fact that a controller is known to provide more relative controllability and less observability, or vice versa for its assigned modes. The investigation will involve initially the fixing of certain baseline parameters to allow a parallel comparison of reasonable results. Then line-of-sight pointing and defocus performance will be generated for comparison among various cases. The simulation model is a version of the so-called Draper-2 space structure model. The next section describes the selected model configuration and discusses its finite element representation. Then the modal control and matrix transformation methods will be explained. The implementation of the simulation program will be discussed. The last sections will detail the investigation, results, conclusions and recommendations. GRA

N86-26074# Stevens Inst. of Tech., Hoboken, N. J. Dept. of Mechanical Engineering.
TIME DOMAIN DESIGN OF ROBUST CONTROLLERS FOR LQG (LINEAR QUADRATIC GAUSSIAN); APPLICATION TO LARGE SPACE STRUCTURES Final Report, May 1984 - Aug. 1985
R. K. YEDAVALLI Dec. 1985 104 p
(Contract F33615-84-K-3606)
(AD-A163635; AFWAL-TR-85-3093) Avail: NTIS HC A06/MF A01 CSCL 20K

The aspect of Robustness for linear multivariable systems in time domain is the central theme of the research under the present contract. Upper bonds on the linear, structured, time varying perturbation of an asymptotically stable linear time invariant regulator are obtained to maintain both stability and acceptable regulation, using Lyapunov approach. Improvement of the proposed measures over existing measures is illustrated with the help of examples. It is shown that by employing a scaling transformation on the nominal system, it is possible to further improve the upper bound. The proposed Perturbation Round Analysis is used to design robust controllers for Linear Quadratic Regulators with structured uncertainity. Introducing quantitative measures called Stability Robustness Index and Performance Robustness Index, design algorithms are presented by which one can achieve a trade off between nominal performance, stability robustness and performance robustness. Applications considered include aircraft control problems, large space structure control problems having uncertain modal data and mode truncation as the perturbations. GRA

N86-26222# Massachusetts Inst. of Tech., Cambridge.
FEEDFORWARD CONTROL OF WAVES IN LATTICE ELEMENTS Technical Report, 1 Feb. - 1 Aug. 1985
J. H. WILLIAMS, JR., G. A. NORRIS, and S. S. LEE 1 Aug. 1985 74 p refs
(Contract F49620-83-C-0092)
(AD-A164009; AFOSR-85-1233TR) Avail: NTIS HC A04/MF A01 CSCL 20K

The motion in a lattice substructural element, within which longitudinal stress waves propagate nondispersively and without attenuation, is assumed to be governed by the classical wave equation. A feedforward controller configuration is proposed to isolate a portion of the substructure from longitudinal wave

disturbances. The governing equations for the propagation of incoming and controller-generated stress waves in the substructure are determined. To prevent instability, the controller must respond to incoming stress waves only, disregarding self-generated outgoing waves. The transfer function for the controlled substructure system is derived. The dependence of the transfer function magnitude on the input waveform frequency as well as on controller error parameters is demonstrated. The ranges of acceptable controller error are determined for the operational goals of disturbance cancellation and disturbance amplitude attenuation. GRA

N86-26357*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC CHARACTERISTICS OF POWER-TOWER SPACE STATIONS WITH 15-FOOT TRUSS BAYS
J. T. DORSEY Jul. 1986 72 p
(NASA-TM-87684; L-16094; NAS 1.15:87684) Avail: NTIS HC A04/MF A01 CSCL 22B

A power tower space station concept which generates power with photovoltaic arrays and where the truss structure has a bay size of 15 ft is described. Rigid body and flexible body dynamic characteristics are presented for a 75-kW Initial Operating Capability (IOC) and 150-kW and 300-kW growth stations. The transient response of the IOC and 300-kW growth stations to shuttle dock, orbit reboost, and mobile remote manipulator system translation loads are studied. Displacements, accelerations, and bending moments at various locations on the IOC and 300-kW growth stations are presented. Author

N86-26367# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
MATHEMATICAL MODELS OF FLEXIBLE SPACECRAFT DYNAMICS: A SURVEY OF ORDER REDUCTION APPROACHES Annual Report, 1984
P. T. L. M. VANWOERKOM 21 Jan. 1985 13 p Presented at 10th IFAC Symp. on Automatic Control in Space, Toulouse, France, 25-29 Jun. 1985
(Contract NIVR-1910)
(NLR-MP-85004-U; B8578426; ETN-86-96974; AD-B098585L)
Avail: NTIS HC A02/MF A01

The usefulness of open loop model order reduction techniques for application of flexible spacecraft dynamics models was assessed. Approaches identified involve parameter optimization; aggregation; singular perturbation; modal dominance; component cost analysis; and internal balancing. The latter three approaches appear to be most meaningful, and convenient in applications. The problem of model order reduction is reviewed, and each of the six approaches is discussed. The latter three approaches are applied to the case of a long, flexible beam in space, controlled with two line torquers. ESA

N86-27359# Technische Univ., Brunswick (West Germany). Inst. fuer Angewandte Mechanik.
CONTROL OF FLEXIBLE STRUCTURES WITH RESPECT TO INFINITY
P. RUGE *In* ESA Second European Space Mechanisms and Tribology Symposium p 35-39 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The transfer matrix method is recommended for studying the stability of linear feedback controlled systems continuous in space and time. The system matrix can be assembled as it is used from finite element methods separately for each continuous member and each joint including control elements. Distributed transfer matrices for the continuous members which contain information up to infinity without poles and truncation errors are used. The calculation of as many eigenvalues as wanted is carried out by trace theorems. ESA

N86-27360# Societe Nationale Industrielle Aerospatiale, Cannes (France). Div. des Systemes Balistiques et Spatiaux.
SOLAR ARRAY DEPLOYMENT SIMULATION USING ADAMS SOFTWARE
C. ROUX and P. FLAMENT *In* ESA Second European Space Mechanisms and Tribology Symposium p 41-46 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The use of ADAMS program to predict dynamic phenomena during deployment of satellite solar arrays is reviewed. The program increases understanding of influences of constituent flexibility during deployment. The program contributes to optimization of the mechanism as to mechanical strength under deployment loads and latching shocks; motorization factor; and layout on the solar array. Prediction of all in orbit deployment cases (including possible failure cases) in order to be sure that no unexpected phenomenon perturb the space flight is also improved. The improved accuracy using ADAMS is verified by test prediction correlation. ESA

N86-27361# Societe Europeenne de Propulsion, Vernon (France).
GIOTTO DESPIN MECHANISM SUBSYSTEM: GENERAL LOOP DESIGN AND POINTING ASPECTS
G. TURIN *In* ESA Second European Space Mechanisms and Tribology Symposium p 47-52 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The Giotto spacecraft despin antenna subsystem used to orient the high gain antenna towards the far Earth, while the satellite is spin stabilized at 15 rpm is described. The despin antenna subsystem control loop behavior in environmental tests and in flight is summarized. The subsystem was launched, unlocked, and put in rotation succesfully. The precision is within the deadband, better than +/- 0.022 degrees (better than half specification). This shows that the concept of a stepper motor in open loop is safe, although an alternative is to increase the damping ratio; simulations show that 1% is sufficient. Strong control on the potential perturbation is also necessary. For example, the least correction must be lower than calculated for a normal linear system. The results from calculation assuming a linear system are optimistic. ESA

N86-27401*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
ADAPTIVE CONTROL OF LARGE SPACE STRUCTURES USING RECURSIVE LATTICE FILTERS Final Report
N. SUNDARARAJAN and G. L. GOGLIA Dec. 1985 80 p
(Contract NAG1-429)
(NASA-CR-177270; NAS 1.26:177270) Avail: NTIS HC A05/MF A01 CSCL 22B

The use of recursive lattice filters for identification and adaptive control of large space structures is studied. Lattice filters were used to identify the structural dynamics model of the flexible structures. This identification model is then used for adaptive control. Before the identified model and control laws are integrated, the identified model is passed through a series of validation procedures and only when the model passes these validation procedures is control engaged. This type of validation scheme prevents instability when the overall loop is closed. Another important area of research, namely that of robust controller synthesis, was investigated using frequency domain multivariable controller synthesis methods. The method uses the Linear Quadratic Guassian/Loop Transfer Recovery (LQG/LTR) approach to ensure stability against unmodeled higher frequency modes and achieves the desired performance. E.R.

N86-27650*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
DYNAMICS OF TETHERED CONSTELLATIONS IN EARTH ORBIT
E. LORENZINI *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 167-203 Jun. 1986
(Contract NAS8-35497; NAS8-36606; RH4-394019)
Avail: NTIS HC A23/MF A01 CSCL 13I

Topics covered include station keeping of single-axis and two-axis constellations; single-axis vertical constellations with low-g platform; single-axis vertical constellations with three masses; deployment strategy; and damping of vibrational modes. B.G.

N86-27655*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
THE DEVELOPMENT OF OPTIMAL CONTROL LAWS FOR ORBITING TETHERED PLATFORM SYSTEMS
P. M. BAINUM *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 325-355 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

A mathematical model of the open and closed loop in orbit plane dynamics of a space platform-tethered-subsatellite system is developed. The system consists of a rigid platform from which an (assumed massless) tether is deploying (retrieving) a subsatellite from an attachment point which is, in general, offset from the platform's mass center. A Langrangian formulation yields equations describing platform pitch, subsatellite tetherline swing, and varying tether length motions. These equations are linearized about the nominal station keeping motion. Control can be provided by both modulation of the tether tension level and by a momentum type platform-mounted device; system controllability depends on the presence of both control inputs. Stability criteria are developed in terms of the control law gains, the platform inertia ratio, and tether offset parameter. Control law gains are obtained based on linear quadratic regulator techniques. Typical transient responses of both the state and required control effort are presented. Author

N86-27656*# British Columbia Univ., Vancouver.
EFFECTS OF DAMPING ON THE CONTROL DYNAMICS OF THE SPACE SHUTTLE BASED ON TETHERED SYSTEMS
V. J. MODI *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 357-382 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

The analysis of the effects of damping on the control dynamics of the space shuttle based on tethered systems suggest that a relatively simple point mass model can provide useful information concering librational dynamics during development and retrieval of the tethered satellites. The results show that a nonlinear tension control strategy in conjunction with a suitable choice of gains and realistic damping can lead to stable retrieval maneuver with amplitudes in pitch and roll limited to acceptable values. Longitudinal and lateral vibrations of the tether are strongly coupled and can lead to the slackening of the tether. Tether vibrations can be controlled quite effectively by speeding up the retrieval at smaller tether length and/or using thruster. E.R.

N86-28113*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL/STRUCTURES INTERACTION STUDY OF TWO 300 KW DUAL-KEEL SPACE STATION CONCEPTS
J. W. YOUNG, F. J. LALLMAN, P. A. COOPER, and D. P. GIESY (PRC Kentron, Inc., Hampton, Va.) May 1986 61 p
(NASA-TM-87679; NAS 1.15:87679) Avail: NTIS HC A04/MF A01 CSCL 22B

The results of an investigation of the influence of structural stiffness of the space station framework on the controllability of two 300 kw class, solar dynamic powered, dual-keel space station designs are presented. The two design concepts differed only in the truss bay dimensions of the structural framework of the stations. Two control studies were made: (1) A study of the interaction of the framework structural response with the reaction control system used for attitude control during an orbital reboost maneuver; and (2) A study of the stability of the space station attitude control system with sensors influenced by the elastic deformations of the station framework. Although both configurations had acceptable control characteristics, the configuration with the larger truss bay dimension and its increased structural stiffness had more attractive characteristics for pointing control of the solar dynamic system during reboost and for attitude control during normal in-orbit operations. Author

N86-28114*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
ANALYTICAL INVESTIGATION OF THE DYNAMICS OF TETHERED CONSTELLATIONS IN EARTH ORBIT, PHASE 2 Quarterly Report, 22 Dec. 1985 - 21 Mar. 1986
E. C. LORENZINI, D. A. ARNOLD, M. D. GROSSI, and G. E. GULLAHORN Mar. 1986 29 p
(Contract NAS8-36606)
(NASA-CR-178846; NAS 1.26:178846; QR-4) Avail: NTIS HC A03/MF A01 CSCL 22B

The g-tuning maneuvers of a 3-mass, vertical tethered system are considered. In particular, the case of reaching a zero-g acceleration level on board the middle mass from a non-zero initial condition is analyzed. A control law that provides a satisfactory transient response is derived. The constellation dynamics in the case of the middle mass travelling from one tether tip to the other is also investigated. Instabilities that take place at the end of the maneuver are analyzed and accommodated by devising suitable damping algorithms. M.G.

N86-28116# Consulenze Generali Roma (Italy).
NUMERICAL EXPERIMENTS ON A CONTROLLED FLEXIBLE STRUCTURE USING DCAF Final Report
F. GRAZIANI and C. ARDUINI Nov. 1984 264 p
(ESA-CR(P)-2159; ETN-86-96861) Avail: NTIS HC A12/MF A01

The Deficiency Corrective Action Program (DCAP) code was used to simulate analog and digital control of a flexible spacecraft for the case of only in-plane motion, without spinning. For analog control, a simple PD scheme with sensors and actuators on the main rigidbody, with control relying on separation between control bandwidth and the lowest elastic frequency, and fully flexible modal control based on LQG programs are studied. For digital control, a problem for sampled sensor signal (at constant sample interval) digital logic and actuation is formulated by a zero order sample and hold device (at constant sample rate). ESA

N86-28411*# Padua Univ. (Italy). Inst. of Applied Mechanics.
A REVIEW OF TETHER INDUCED DYNAMICAL FEATURES
S. BERGAMASCHI *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 103-116 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

The simplest mathematical model used for the simulation of TSS motion is considered in order to review the dynamics of tethers. This model is discussed. Also reviewed are elasticity effects, perturbation sources, orbit eccentricity and natural frequencies. Tethered systems provide a unique opportunity for skilled measurement activities in space. Some of the experiments envisaged require the measurement of very small mechanical quantities. This implies that the level of dynamical noise on instruments output be low or that system response to excitation, either external or internal, be sufficiently known. In this respect, the first TSS flights will be very useful, but much work will be needed in order to have reliable estimates of structural damping in different future systems. E.R.

N86-28981*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NONLINEAR DYNAMIC ANALYSIS OF DEPLOYING FLEXIBLE SPACE BOOMS
P. E. MCGOWAN and J. M. HOUSNER Sep. 1985 34 p
(NASA-TM-87617; NAS 1.15:87617) Avail: NTIS HC A03/MF A01 CSCL 22B

A fundamental investigation of the planar deployment and lock-up of two flexible boom type appendages which have attached

tip masses and are connected to a central rigid body through a rotational spring is presented. Nondimensional parameters are identified and it is shown that, in general, the solution depends only on two mass ratios and one nondimensional stiffness parameter. Results are presented for boom tip deflections, deployment time and root moments at lock-up. A threshold value of the nondimensional stiffness parameter is identified beyond which boom deflections become large. Also, a thorough examination of the effect of nonlinear terms in the equations governing the deployment phase is performed. Nonlinear terms in the deployment equations due to kinematics and structural deformation are required to predict more accurately boom deflections, but retention of an inconsistent set of nonlinear terms leads to erroneous results. In particular, retaining nonlinear kinematic terms while neglecting nonlinear structural terms can produce inaccurate results even below the threshold stiffness value. Author

N86-28983*# North Carolina Univ., Charlotte. Dept. of Electrical Engineering.
DYNAMICS AND CONTROL OF FLEXIBLE SPACECRAFT DURING AND AFTER SLEWING MANEUVERS Semiannual Progress Report, 1 Nov. 1985 - 30 Apr. 1986
Y. P. KAKAD 30 Apr. 1986 25 p
(Contract NAG1-535)
(NASA-CR-177027; NAS 1.26:177027) Avail: NTIS HC A02/MF A01 CSCL 22B

The dynamics and control of slewing maneuvers of a large flexible spacecraft, namely, NASA Spacecraft Control Laboratory Experiment (SCOLE) test article are studied. The dynamical equations obtained for slewing maneuvers are highly nonlinear and coupled. The maneuver is expressed in terms of four Euler parameters and is specified as the angular displacement about an arbitrary axis. The slew maneuver control problem is developed in terms of rigid-body slewing and suppression of two elastic modes is analyzed using the method of nonlinear decoupling. Author

N86-28985# Control Dynamics Co., Huntsville, Ala.
ASCOT (ADVANCED STRUCTURAL CONTROL TECHNIQUES) Final Report, Nov. 1983 - Jan. 1985
S. M. SELTZER, D. K. TOLLISON, T. G. HOWSMAN, R. D. IRWIN, and W. P. MAGGARD Sep. 1985 164 p
(Contract F30602-84-C-0012; ARPA ORDER 4828; DA PROJ. D82-8)
(AD-A165917; CDC-223-1284-FR-ASC; RADC-TR-85-166) Avail: NTIS HC A08/MF A01 CSCL 09B

This is the Control Dynamics Company final technical report on Advanced Structural Control Techniques (ASCOT). Included is the description and application of a novel technique for the design of low order digital controllers for very high order system models. Also included is an investigation of a digital prefiltering technique which incorporates non-uniform rate sampling. GRA

N86-29272*# Stanford Univ., Calif. Guidance and Control Lab.
THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF SENSOR LOCATION FOR OPTIMAL AEROELASTIC SYSTEM STATE ESTIMATION Final Report
G. LIU Sep. 1985 182 p
(Contract NSG-4002)
(NASA-CR-177115; NAS 1.26:177115; SU-SUDAAR-552) Avail: NTIS HC A09/MF A01 CSCL 20K

One of the major concerns in the design of an active control system is obtaining the information needed for effective feedback. This involves the combination of sensing and estimation. A sensor location index is defined as the weighted sum of the mean square estimation errors in which the sensor locations can be regarded as estimator design parameters. The design goal is to choose these locations to minimize the sensor location index. The choice of the number of sensors is a tradeoff between the estimation quality based upon the same performance index and the total costs of installing and maintaining extra sensors. An experimental study for choosing the sensor location was conducted on an aeroelastic system. The system modeling which includes the unsteady aerodynamics model developed by Stephen Rock was improved. Experimental results verify the trend of the theoretical predictions of the sensor location index for different sensor locations at various wind speeds. Author

N86-29890# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ACOSS ELEVEN (ACTIVE CONTROL OF SPACE STRUCTURES) S Final Report, Oct. 1983 - Jul. 1984
D. R. HEGG, G. J. KISSEL, N. H. MCCLAMROCH, M. J. VILLALBA, and I. G. ROSEN Sep. 1985 286 p
(Contract F30602-81-C-0180; ARPA ORDER 3655; AF PROJ. C65-5)
(AD-A165864; CSDL-R-1721; RADC-TR-85-165) Avail: NTIS HC A13/MF A01 CSCL 15D

The main lines of effort in flexible structure control have been: (1)synthesis of reduced order control for vibration suppression; (2)system identification, with special attention to the resolution of closely spaced modes; and (3)generation of smooth large angle slew control. Highlights of current results are as follows. A final account is given of insights obtained during a systematic investigation of mutual interactions within the overall active control systhesis process between reduced order modeling, actuator and sensor selection, and controller feedback strategy determination. Using linear multivariate loop transfer recovery, full order stability robustness to unmodeled high frequency dynamics in the presence of wideband disturbances is demonstrated on ACOSS model no. 2. A perspective on electromechanical actuator dynamics modeling is presented. Interface constraints with the controller synthesis process associated with the use of high resolution spectrum estimation for reduced order modeling are analyzed. Parametric use of the data sampling period to assist in the resolution of closely spaced modes is discussed or demonstrated. An improved technique for parameter estimation in distributed parameter systems is generated. Author

N86-29891# Massachusetts Inst. of Tech., Cambridge.
WAVE PROPAGATION MEASUREMENTS ON TWO-DIMENSIONAL LATTICE Technical Report, 1 Feb. - 15 Sep. 1985 Sep. 1985
J. H. WILLIAMS, JR., J. J. ZHANG, and S. S. LEE 15 Sep. 1985 32 p
(Contract F49620-83-C-0092)
(AD-A166207; AFOSR-86-0095TR) Avail: NTIS HC A03/MF A01 CSCL 22B

Wave propagation characteristics of large space structures (LSS) affect their performance, integrity and the ability to nondestructively assess their integrity. In this study, wave propagation characteristics of a periodic lattice structure are determined experimentally. The structure considered is an aluminum multi-bay planar lattice. Two ultrasonic piezoceramic longitudinal transducers are mounted at various locations on the structure. Wave measurements are obtained by injecting an impulsive load via the transmitting transducer and recording the response via the receiving transducer. The waves injected into the structure are longitudinal waves, transverse to the surface, although a complex stress distribution which may be described by directivity functions is actually realized. The impulsive loading signal has a broad frequency spectrum containing frequencies greater than 0.5 MHz. This preliminary experimental study demonstrates that wave propagation characteristics of a lattice structure can be obtained. In particular, the wave speed, the frequency at the maximum amplitude of the output spectrum, and the attenuation of the maximum amplitude of the output spectrum per lattice bay traversed appear to be useful parameters in the characterization of wave propagation properties of LSS. Further study should investigate the effects of boundaries, lattice member connectivities, and structural defects on these parameters. GRA

N86-29892# Massachusetts Inst. of Tech., Cambridge.
FAILURE PROPAGATION IN CONTINUUM MODELS OF LSS (LARGE SPACE STRUCTURES), PART 1 Technical Report, 1 Sep. - 1 Nov. 1985
J. H. WILLIAMS, JR. and S. S. LEE 1 Nov. 1985 30 p
(Contract F49620-85-C-0148)
(AD-A166208; AFOSR-86-0094TR-PT-1) Avail: NTIS HC A03/MF A01 CSCL 13M

Large space structures (LSS) can often be modelled adequately as equivalent anisotropic continua. In this study concepts in failure mechanics and wave propagation are applied to analyze the dynamic failure (fracture, buckling, joint disassembly, etc.) and failure arrest behavior of such an equivalent continuum. For simplicity, the equivalent continuum is assumed to be orthotropic. Furthermore, the transverse shear deformation of the equivalent continuum is assumed to dominate. Double cantilever beam models are well established fracture mechanics models in the study of crack propagation in a continuum. An orthotropic double cantilever shear beam (DCSB) model is adopted here to study Mode I dynamic failure (which for convenience is assumed to be fracture) and arrest in continuum models of lattice structures. The orthotropic DCSB model consists of both a primary material and a finite width arrester section. The DCSB model has predicted that under the proper conditions the crack may arrest when any of the following conditions is satisfied: 1) When the initial reflected disturbance catches the crack tip, before the crack tip reaches the arrester section; 2) When the crack tip enters the arrester section; 3) When the crack tip exits the arrester section; or 4) When the initial reflected disturbance catches the crack tip, after the crack tip has exited from the arrester section. It is shown that condition (1) is absolute, meaning that the crack is always arrested. GRA

N86-30652*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STIFFNESS CONTROL OF LARGE SPACE STRUCTURES
J. C. CHEN and J. L. FANSON *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 368-373 1985 Sponsored by NASA
Avail: NTIS HC A99/MF E03 CSCL 01B

A method of using internal force producing dual element/actuators for vibration suppression of large space structures is proposed. The technique is applied to a vibrating string and to a low order system. Response feedback control for the vibrating string and selected modal control are used for achieving the modal damping. The actuators may be electrically powered and are suitable for structures with extremely low rigidity. ESA

N86-30653# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
ASPECTS OF ACTIVE ISOLATION AS APPLIED TO A SATELLITE STRUCTURE WITH SHAPE PRECISION PAYLOAD
W. CHARON *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 374-380 1985
(Contract ESTEC-5326/83-NL-PB(SC))
Avail: NTIS HC A99/MF E03

Active vibration control of flexible spacecraft is discussed. The satellite structure is divided into two rigid modules: the shape precision payload and a vibrating equipment module containing the attitude sensors and the attitude actuators. The two modules are connected by six spring-force actuator devices considered together to determine the isolation control forces. These connections transmit the low-frequency attitude control to the precision payload but attenuate the higher-frequency disturbances whose shape and magnitude are unknown to the isolation control system. ESA

N86-30682*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TEST AND ANALYSIS CORRELATION FOR STRUCTURAL DYNAMIC SYSTEMS
B. K. WADA and J. C. CHEN *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 632-647 1985 Sponsored by NASA
Avail: NTIS HC A99/MF E03 CSCL 01B

Activities in modifying a structural mathematical model to correlate with its modal test results are summarized. Results from the Viking and Galileo spacecraft, and developments in the parameter estimation of structural mathematical models of large flexible structures using multiple boundary condition tests are presented. ESA

N86-30683*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC VERIFICATION OF VERY LARGE SPACE STRUCTURES
B. R. HANKS *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 648-655 1985
Avail: NTIS HC A99/MF E03 CSCL 01B

A research program in spacecraft structures, structural dynamics, and controls verification using a relatively large, flexible beam as a focus is introduced. This research effort addresses fundamental problems applicable to the verification of large, flexible space structures and combines ground tests, flight behavior prediction, and instrumented orbital tests. The program is expected to produce quantitative results for use in improving the validity of ground tests for verifying flight performance analyses. ESA

N86-30684# Technische Hochschule, Aachen (West Germany). Inst. fuer Leichtbau.
RECONSTRUCTION OF FORCING FUNCTIONS BASED ON MEASURED STRUCTURAL RESPONSES
H. OERY, H. GLASER, and D. HOLZDEPPE *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 656-668 1985 Sponsored by Deutsche Forschungsgemeinschaft, ESA, and MBB/Erno G.m.b.H.
Avail: NTIS HC A99/MF E03

A structural analysis procedure to reconstruct the significant parts of the forcing function time-histories based on a restricted number of test records is presented. Use of the inverse application of the phase-plane method and Williams' method is proposed. The procedure is based on the fact that very slowly varying loads induce deformations, which can be determined using the stiffness matrix only. It can be applied to aerospace structures and to earthquake engineering. ESA

N86-30687# Department of Communications, Ottawa (Ontario). David Florida Lab.
VIBRATION QUALIFICATION AT THE DAVID FLORIDA LABORATORY
R. MAMEN *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 683-688 1985
Avail: NTIS HC A99/MF E03

A facility for spacecraft integration and environmental tests to qualify flight hardware is presented. Its thermal vacuum, mass properties, radio frequency, and vibration testing services are used for programs ranging from black box level to complete spacecraft and space systems. Its comprehensive structural qualification capabilities were selected for the Remote Manipulator System, ANIK-D, Brazilsat, and L-Sat. ESA

N86-30800*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATION OF THE LQG/LTR TECHNIQUE TO ROBUST CONTROLLER SYNTHESIS FOR A LARGE FLEXIBLE SPACE ANTENNA
S. M. JOSHI, E. S. ARMSTRONG, and N. SUNDARARAJAN (Old Dominion Univ., Norfolk, Va.) Sep. 1986 64 p
(NASA-TP-2560; L-16076; NAS 1.60:2560) Avail: NTIS HC A04/MF A01 CSCL 22B

The problem of synthesizing a robust controller is considered for a large, flexible space-based antenna by using the linear-quadratic-Gaussian (LQG)/loop transfer recovery (LTR) method. The study is based on a finite-element model of the 122-m hoop/column antenna, which consists of three rigid-body rotational modes and the first 10 elastic modes. A robust compensator design for achieving the required performance bandwidth in the presence of modeling uncertainties is obtained using the LQG/LTR method for loop-shaping in the frequency domain. Different sensor actuator locations are analyzed in terms of the pole/zero locations of the multivariable systems and possible best locations are indicated. The computations are performed by using the LQG design package ORACLS augmented with frequency domain singular value analysis software. Author

N86-30801*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF MODEL ERROR ON CONTROL OF LARGE FLEXIBLE SPACE ANTENNA WITH COMPARISONS OF DECOUPLED AND LINEAR QUADRATIC REGULATOR CONTROL PROCEDURES
H. A. HAMER and K. G. JOHNSON Sep. 1986 52 p
(NASA-TP-2604; L-16114; NAS 1.60:2604) Avail: NTIS HC A04/MF A01 CSCL 22B

An analysis was performed to determine the effects of model error on the control of a large flexible space antenna. Control was achieved by employing two three-axis control-moment gyros (CMG's) located on the antenna column. State variables were estimated by including an observer in the control loop that used attitude and attitude-rate sensors on the column. Errors were assumed to exist in the individual model parameters: modal frequency, modal damping, mode slope (control-influence coefficients), and moment of inertia. Their effects on control-system performance were analyzed either for (1) nulling initial disturbances in the rigid-body modes, or (2) nulling initial disturbances in the first three flexible modes. The study includes the effects on stability, time to null, and control requirements (defined as maximum torque and total momentum), as well as on the accuracy of obtaining initial estimates of the disturbances. The effects on the transients of the undisturbed modes are also included. The results, which are compared for decoupled and linear quadratic regulator (LQR) control procedures, are shown in tabular form, parametric plots, and as sample time histories of modal-amplitude and control responses. Results of the analysis showed that the effects of model errors on the control-system performance were generally comparable for both control procedures. The effect of mode-slope error was the most serious of all model errors. Author

N86-30803# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
CONTROL OF LARGE FLEXIBLE SYSTEMS BY SPATIAL MODAL INPUT-DISTRIBUTION CONTROL M.S. Thesis
C. V. BENDORF 1985 113 p
(AD-A166912; AFIT/CI/NR-86-47T) Avail: NTIS HC A06/MF A01 CSCL 22B

A common problem in controlling a large flexible structure with a reduced order model is the excitation of the residual (non-modeled) modes by the control inputs resulting in control spillover. In this thesis a new approach to eliminate control spillover is examined. This approach, based on the independent modal-space control method, uses a finite number of spatially distributed input points to eliminate control spillover. Control of an undamped beam and a finite degree of freedom truss is accomplished through computer simulation. The results of the seven example problems shows that this new approach does effectively eliminate control spillover. GRA

N86-31336*# Columbia Univ., New York. Dept. of Civil Engineering and Engineering Mechani
VIBRATION AND STRUCTUREBORNE NOISE IN SPACE STATION Progress Report, 1 Jan. - 30 Jun. 1986
R. VAICAITIS 1986 23 p
(Contract NAG1-541)
(NASA-CR-177146; NAS 1.26:177146) Avail: NTIS HC A02/MF A01 CSCL 20A

Analytical models and computer programs for structural response calculations under action of mechanical point loads were developed for single wall shells (composite or aluminum), double wall shells (composite or aluminum), and single wall or double wall circular plates (aluminum). The design configuration of the habitability modules of the space station concept are expected to be discretely stiffened cylindrical shells with truncated cone type end caps or flat but stiffened circular end plates. Analytical formulations and response calculations were performed for the case where the stiffened shell is represented by an orthotropic shell model. The natural frequencies can be calculated. For application to low frequency (below 1000Hz) vibrations and noise generation, such a model might be adequate to evaluate vibration and noise transmission characteristics of space station habitability modules. Parametric studies are now being performed to assess interior noise environment inside a habitability module to mechanically induced vibrations. B.G.

N86-31631*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
THE INVESTIGATION OF TETHERED SATELLITE SYSTEM DYNAMICS Quarterly Report, 15 Feb. - 14 May 1986
E. C. LORENZINI Jun. 1986 113 p
(NASA-CR-178895; NAS 1.26:178895; QR-7) Avail: NTIS HC A06/MF A01 CSCL 22B

The analysis of the rotational dynamics of the satellite was focused on the rotational amplitude increase of the satellite, with respect to the tether, during retrieval. The dependence of the rotational amplitude upon the tether tension variation to the power 1/4 was thoroughly investigated. The damping of rotational oscillations achievable by reel control was also quantified while an alternative solution that makes use of a lever arm attached with a universal joint to the satellite was proposed. Comparison simulations between the Smithsonian Astrophysical Observatory and the Martin Marietta (MMA) computer code of reteival maneuvers were also carried out. The agreement between the two, completely independent, codes was extremely close, demonstrating the reliability of the models. The slack tether dynamics during reel jams was analytically investigated in order to identify the limits of applicability of the SLACK3 computer code to this particular case. Test runs with SLACK3 were also carried out. Author

N86-31636# National Aerospace Lab., Amsterdam (Netherlands). Spaceflight Div.
ATTITUDE CONTROL OF SPACECRAFT: AN OVERVIEW OF RECENT DEVELOPMENTS AND RESEARCH
T. ZWARTBOL 27 Jun. 1985 24 p In DUTCH; ENGLISH summary Submitted for publication
(NLR-MP-85055-U; B8664362; ETN-86-97681; AD-B101030L)
Avail: NTIS HC A02/MF A01

The application of modern control techniques for the development of spacecraft attitude estimation and control algorithms is reviewed. Control theories, and the mathematical modeling of the systems such as optical systems, flexible spacecraft, and liquid sloshing in microgravity are treated. The Modular Attitude Control System (MACS) is presented. The MACS test and simulation assembly, built for ESA, is described. ESA

N86-31643# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
DYNAMICS OF FLEXIBLE SPACECRAFT: AN ANALYSIS OF APPROACHES TOWARDS MATHEMATICAL MODEL ORDER REDUCTION
P. T. L. M. VANWOERKOM 16 Apr. 1985 202 p
(Contract NIVR-1910)
(NLR-TR-85068-U; B8665500; ETN-86-98038) Avail: NTIS HC A10/MF A01

Reduction of the mathematical order (i.e., of the mathematical complexity) of the open loop spacecraft dynamics model with minimal loss of model accuracy is discussed. Approaches to open loop model order reduction were analyzed regarding application to dynamic models of flexible spacecraft. Parameter optimization, aggregation, singular perturbation, modal dominance, and component cost analysis were compared. The latter two approaches appear to be most meaningful and convenient amongst the five. ESA

N86-32512*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
RELIABILITY ISSUES IN ACTIVE CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES Semiannual Status Report, 16 May - 15 Nov. 1985
W. E. VANDERVELDE 4 Feb. 1986 14 p
(Contract NAG1-126)
(NASA-CR-179758; NAS 1.26:179758) Avail: NTIS HC A02/MF A01 CSCL 22B

Efforts in this reporting period were centered on four research tasks: design of failure detection filters for robust performance in the presence of modeling errors, design of generalized parity relations for robust performance in the presence of modeling errors, design of failure sensitive observers using the geometric system theory of Wonham, and computational techniques for evaluation of the performance of control systems with fault tolerance and redundancy management Author

N86-32513*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
ANALYTICAL INVESTIGATION OF THE DYNAMICS OF TETHERED CONSTELLATIONS IN EARTH ORBIT, PHASE 2
E. C. LORENZINI Jul. 1986 59 p
(Contract NAS8-36606)
(NASA-CR-178901; NAS 1.26:178901; QR-5) Avail: NTIS HC A04/MF A01 CSCL 22A

The analytical model and software implementation of n-mass, three dimensional tethered systems are discussed. The newly developed computer code is then used for simulating the 3-dimensional dynamics of a 4-mass tethered system. The 4-mass tethered system is designed in order to provide a micro-g environment on board the space station while variable-g experiments are performed on a laboratory moving along the upward tether segment. Extensive simulation runs illustrate both the undamped, free response and the damped dynamics response of the system. Passive longitudinal dampers and subsequently active damping algorithms, effective against the in-plane dynamics, are added to the system. Their separate effects upon the various vibrational modes are clearly shown by relevant simulation runs. Author

N86-32516# Societe Nationale Industrielle Aerospatiale, Cannes (France).
INFLUENCE OF STRUCTURAL PARAMETER UNCERTAINTIES ON FLEXIBLE SPACE STRUCTURAL CONTROL PERFORMANCES
L. PASSERON 1986 29 p Presented at American Control Conference Workshop on Identification and Control of Flexible Space Structures, San Diego, Calif., 4-8 Jun. 1984
(SNIAS-861-440-104; ETN-86-97613) Avail: NTIS HC A03/MF A01

A geometric approach to check controllability and observability properties of light flexible space structures is presented. A matrix model of general autonomous linear systems is described. The system properties are decoupled on each characteristic subspace of the respective matrices. Straightforward criteria expressions are given. A quantitative analysis of the system properties versus parametric uncertainties is given. The results are applied to large flexible space structures. It is shown that the method enables a thorough investigation of structural parameter uncertainties on observability and controllability properties. ESA

06

ELECTRONICS

Includes techniques for power and data distribution, antenna RF performance analysis, communications systems, and spacecraft charging effects.

A86-30714
MILLIMETER-WAVE RANGE FOR THE QUICK EVALUATION OF LARGE REFLECTOR ANTENNAS WITH COMPLEX FEEDS
S. LAZAR (Aerospace Corp., Electronics Research Laboratory, El Segundo, CA) International Journal of Infrared and Millimeter Waves (ISSN 0195-9271), vol. 7, Feb. 1986, p. 245-250.
(Contract F04701-84-C-0085)

An automated millimeter-wave antenna range capable of measuring primary-feed structure patterns and transferring this data to a mainframe computer for secondary pattern computation is described. Its applicability to the rapid evaluation of complex feed structures as used in a Cassegrain antenna is illustrated. An example of a reflector antenna is compared to a measured pattern. Author

A86-31923
SOME ELECTRICAL PROPERTIES OF C.F.R.P. REFLECTOR ANTENNAS
A. G. P. BOSWELL and D. C. BREWSTER (General Electric Co., PLC, Research Laboratories, Chelmsford, England) IN: International Conference on Antennas and Propagation (ICAP 85), 4th, Coventry, England, April 16-19, 1985, Proceedings . London and New York, Institution of Electrical Engineers, 1985, p. 358-361.

A surface-impedance matrix is used to analyse a carbon-fiber reinforced plastic (CFRP) reflecting surface, and the effects on cross polarized radiation from a shaped reflector using this material are discussed. Measurements were made, in the frequency range of 11.6-14.6 GHz, of the reflection coefficients of a 0.3-mm CFRP sample, and from these a surface impedance was deduced. The analysis is applied to a physical-optics computer simulation of an 11- and 14-GHz North American communication satellite antenna with a 1.2-m circular aperture front-fed offset a reflector. The effect on the cross-polar performance of the antenna was generally found to be small, however, an intrinsic cross-polar level of -45 dB was shown to have a significant effect. R.R.

A86-35194#
ALTERNATIVE SPACE POWER SYSTEMS
W. WESTPAL (Telefunken AG, Frankfurt am Main, West Germany) and G. KRUELLE (DFVLR, Cologne, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985, Paper. 17 p. refs

Viable alternative primary power systems which would be operational when space power growth surpasses solar array appropriability are investigated,with reference to the development of the Space Station. An operational comparison is made between photovoltaic, solar-dynamic, and nuclear dynamic concepts with regard to weight, exposed area, safety, and reliability. Energy converters under consideration include thermodynamic cycles (Brayton, Rankine, and Stirling), the thermionic converter, the combined thermionic-Brayton system, and a thermoelectric converter. It is concluded that, as compared to a photovoltaic/battery-storage system, solar- or nuclear-dynamic

systems reach higher efficiencies, incorporate a more effective buffer storage for shadow phases, and drastically reduce the exposed collecting area. K.K.

A86-36671
SOLAR ENERGY CONVERSION SYSTEMS FOR POWER PLANTS IN SPACE - A COMPARATIVE ANALYSIS AND PROSPECTS FOR DEVELOPMENT [SISTEMY PREOBRAZOVANIIA SOLNECHNOI ENERGII DLIA KOSMICHESKIKH ENERGOSTANTSII - SRAVNITEL'NYI ANALIZ I PERSPEKTIVY RAZVITIIA
V. A. GRILIKHES IN: Conversion of solar energy . Moscow, Izdatel'stvo Nauka, 1985, p. 60-74. In Russian. refs

Solar energy conversion methods and systems for orbital solar power plants are reviewed with reference to data in the literature. In particular, attention is given to general requirements for orbital solar energy conversion systems, their principal characteristics, principal types of solid-state photovoltaic cells, and thermoelectric conversion systems. A comparative analysis is made of the performance of photovoltaic and thermal systems, and directions of further research in this field are outlined. V.L.

A86-39480*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
KALMAN-LIKE ESTIMATION FOR STATIC DISTRIBUTED SYSTEMS ANTENNA SHAPE FROM RADIATION MEASUREMENTS
G. RODRIGUEZ and R. E. SCHEID, JR. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 39-60. NASA-supported research.

This paper advances an approach to the determination of shape of static distributed systems. It also illustrates the application of the approach to the problems of surface diagnosis of large parabolic reflectors. The estimation methods developed combine in an optimal sense the information from an elliptic model of the structure and from measurements of the structural deflection and of the far-field pattern changes due to the structural deformation. The estimators have a predictor-corrector structure, quite similar to that of a Kalman filter. The system model is first used to obtain a predicted estimate. A correction term is then added to the prediction to obtain the final state estimate. The relative weighting between prediction and correction terms is determined by an estimator gain. As in a Kalman filter, the estimator gain can be expressed in terms of the state estimation error covariance. Author

A86-40529* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
COMMUNICATIONS AND TRACKING - THE KEYS TO SPACE STATION UTILIZATION
R. S. SAWYER, O. L. SCHMIDT, and O. L. GRAHAM (NASA, Johnson Space Center, Houston, TX) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 11-1 to 11-11.

An overview of the Space Station Communications and Tracking System is presented, along with a description of its component parts and the numerous interacting control links. Emphasis is given to explaining the television and data control routing within the confines of the system. The growth expectations for the Space Station are discussed in light of the communications and tracking requirements. Author

A86-40597#
ELECTROSTATIC CHARGING AND ARC DISCHARGES ON SATELLITE DIELECTRICS SIMULATED BY ELECTRON BEAM
H. FUJII, Y. SHIBUYA (Mitsubishi Electric Corp., Manufacturing Development Laboratory, Amagasaki, Japan), T. ABE, R. KASAI (Mitsubishi Electric Corp., Kamakura, Japan), and H. NISHIMOTO (National Space Development Agency of Japan, Tsukuba Space Center, Sakura) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 156-163. refs
(AIAA PAPER 86-1191)

This paper describes the electrostatic charging and discharge phenomena of dielectric materials for spacecraft by electron-beam irradiation simulating the hot plasma in space. Thermal control materials were used as the dielectric materials tested. Charge accumulation in the dielectric irradiated with the partially penetrating mono-energetic electron beam causes a large potential on the surface. When the large surface potential reaches a critical value, arc discharge occurs. The rate of occurrence of the discharge increases with the electron energy and the electron beam current density. The characteristics of the discharges, however, depend on the material. Author

A86-41018
THE USE OF ELECTROSTATIC NOISE TO CONTROL HIGH-VOLTAGE DIFFERENTIAL CHARGING OF SPACECRAFT
D. E. HASTINGS (MIT, Cambridge, MA) Journal of Geophysical Research (ISSN 0148-0227), vol. 91, May 1, 1986, p. 5719-5724. refs

High differential charging is known to occur on geostationary satellites between two electrically isolated pieces of the same material. This happens because current balance with ambient space environment on each surface can be satisfied by different surface potentials. Three such potentials (two stable and one unstable) are found for the two-Maxwellian plasmas considered in this study and in the absence of photoelectron mission. Thus two isolated surfaces can have significantly different potentials leading, possibly, to electrostatic discharges. It is shown that, in an electrostatically noisy environment, one of the surface potentials is more likely to occur than the others and thus both surfaces will achieve this most probable potential independent of their previous charging history. The time for this to happen, while dependent on the characteristics of the roots, can be relatively short and may limit this type of differential charging. This effect is examined in quantitative detail for the environments measured by the ATS-5 and SCATHA satellites. Author

A86-44733
INVESTIGATION OF ARRAYS OF HIGH-Q MICROSTRIP ANTENNAS [ISSLEDOVANIE ANTENNYKH RESHETOK VYSOKODOBROTNYKH POLOSKOVYKH IZLUCHATELEI]
B. A. PANCHENKO and S. T. KNIAZEV Antenny (ISSN 0320-9601), no. 32, 1985, p. 120-123. In Russian. refs

A variational method is used to determine the impedance characteristics of high-Q microstrip antennas in large linear arrays. Numerical results are obtained and analyzed. B.J.

A86-44906
DECREASED CREEP FOR INCREASED SPACE POWER
J. F. MORRIS (Arizona State University, Tempe) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 24, no. 1, 1986, p. 77-95. refs

Projected space needs for increased space power, higher spacecraft weights, and higher operating temperatures underline the necessity for decreased creep. Recent developments in the understanding of mechanisms contributing to or detracting from creep are discussed. Important diffusion effects on creep involve solute, additive and/or impurity segregation at lattice interruptions such as dislocations, grain boundaries, and surfaces. Pure metal creep curves depict the time trace of strain during plastic deformation caused by prolonged loading. Various creep categories and related processes are considered, and methods of

counteracting creep are discussed. A specific method for decreased creep in high-temperature low vapor pressure space ultralloys predicts improved ductility, increased recrystallization resistance and simplified processing. R.R.

A86-45706*#
PROTECTING SPACECRAFT FROM ATOMIC OXYGEN
L. J. LEGER and J. T. VISENTINE (NASA, Johnson Space Center, Houston, TX) Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 32-35.

Findings are reported from Space Shuttle flights STS-3, 4, 5, and 8 regarding the degradation of materials exposed to atomic oxygen in low earth orbit. Atomic oxygen, a strong oxidizing agent, is present in low concentrations at such altitudes, and a spacecraft can sweep up considerable volumes of it at orbital velocities of 5 miles/s, especially if mission lifetimes are measured in years or decades. Material loss has been found to be a function of the fluence (the number of oxygen atoms striking a unit area of surface over a given period); fluence is proportional to atmospheric density, orbital velocity, surface attitude relative to velocity vector, and duration of exposure. Atmospheric density depends first on altitude and second on the phase of the 11-year solar activity cycle. Metals, in the experiments, reacted less than nonmetals. Graphs and a table are included, permitting calculation of how far a surface of various organic materials will recede on a spacecraft in low earth orbit. The limited data base on atomic oxygen interactions with materials, using both Shuttle flight experiments and ground-based facilities must be augmented. Space Station design is imminent, and the understanding of such interactions is critical to the success of that design. D.H.

A86-46578
A CORRECTION FOR CONTINUOUS ROTATION IN MEASUREMENTS OF THE NEAR FIELD [CORRECTION DE ROTATION CONTINUE EN MESURES DE CHAMPS PROCHES]
M. MOSTAFAVI and J.-C. BOLOMEY (Ecole Superieure d'Electricite, Gif-sur-Yvette, France) Annales des Telecommunications (ISSN 0003-4347), vol. 41, Mar.-Apr. 1986, p. 178-182. In French. refs
(Contract ESA-5272/82; CNES-84-5393)

A correction factor is defined for use when obtaining meridional measurements of the near field of a rotating antenna in order to predict the radiation pattern in the far field. The technique resides on translation of the measurement data in either a spherical or a cylindrical coordinate system and Fourier transformations of the harmonic components in a time frame commensurate with the angular rotation of the antenna. A phase compensation term is thus obtained to predict the far field radiation pattern. It is noted that the method is applicable only if the measurement rate of the near field radiation exceeds the angular rate of rotation of the antenna. The factor is expected to be of use in predicting the far field radiation patterns of large space antennas. M.S.K.

A86-46939#
SPACE STATION COMMUNICATION NETWORKS
T. R. SAVAGE (TRW, Inc., Redondo Beach, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 9 p. refs
(AIAA PAPER 86-2307)

The selection of a proper transmission media for Space Station communications is examined. A model for evaluating different network topologies based on complexity, robustness, connectivity, and wastefulness is developed. The usefulness of the model is studied by applying it to the analysis of dual-linear bus, single-linear bus, ring, and star network topologies. The characteristics and capabilities of a coaxial broad-band cable and a fiber optic cable are compared in terms of topological considerations. The advantages provided by the coaxial broad-band cable are described. It is noted that the coaxial broad-band cable is applicable for near-term communications on the Space Station; however, the possible future transmission of high-speed data will require the use of fiber optics. I.F.

A86-47335
A NEW UNDERSTANDING OF BREAKDOWNS IN THE DAY SECTIONS OF GEOSYNCHRONOUS ORBIT
L. LEVY (ONERA, Centre d'Etudes et de Recherches de Toulouse) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 467-474. refs

A unified theory for spacecraft charging is proposed whereby the satellite anomaly distribution is taken into account. The question of whether energy or intensity is the more significant worst-case environmental parameter is addressed as well as the question of where on the orbit the highest energies or intensities are encountered. It is shown that there is no unique 'worst case'. The day-side environment will be the worst-case for pure dielectrics (provided they are in the shadow) while the night side will be the worst-case for conductive dielectrics. The worst-case for the latter is the occurrence of substorms. K.K.

A86-47336
STATUS OF CRITICAL ISSUES IN THE AREA OF SPACECRAFT CHARGING
J. E. NANEVICZ and R. C. ADAMO (SRI International, Menlo Park, CA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 475-484. refs

Attention is given to the major technical considerations important to spacecraft charging. These include the space environment, environmental interactions with satellite surfaces, discharge characteristics, coupling to systems and systems affected. The interference control problem is discussed and it is shown how its severity is dependent upon the properties of the source, the coupling path and the victim. Strategies for source elimination, coupling control and victim hardening are proposed. The engineering aspects of the spacecraft charging problem could benefit from the following: (1) identification of materials displaying susceptibility in orbit, (2) quantification of discharge characteristics in orbit and (3) characterization of internal noise pulse environments on typical satellites. It is concluded that a better understanding of the actual in-orbit discharge process and its characteristics is needed. This information could most accurately be obtained by taking advantage of payload opportunities so as to incorporate properly designed discharge detection and characterization instrumentation on present and future spacecraft programs. K.K.

A86-49561#
ELECTRICAL POWER SYSTEM INTEGRATION FOR THE SPACE STATION
R. HINNRICHS, J. WHITSETT, R. PHILLIPS, W. ALLEN, and J. CECKA (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 14 p. refs
(AIAA PAPER 86-2351)

The design and development of the Space Station electrical power system (EPS), the complexities of which include high electrical power requirements, multiple ac and dc power sources, and diverse loads located throughout a large space structure, are discussed. A series of trade studies conducted to define the baseline EPS architecture and preliminary design implementation are described. An Initial Operating Capabilities power generation system, providing 50 kW of photovoltaic power along with a ring power-distribution architecture, has been baselined. Special attention is given to a hierarchical software/processor which provides monitoring and control functions for the EPS. Multiple block diagrams are included. I.S.

A86-50286*# Lockheed Engineering and Management Services Co., Inc., Houston, Tex.
A DISTRIBUTED ARRAY ANTENNA SYSTEM
R. SHAW and J. KOVITZ (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IEEE Microwave Theory and Techniques Symposium, Baltimore, MD, June 2-5, 1986, Paper. 4 p.
(Contract NAS9-15800)

The Space Station communication system will use microwave frequency radio links to carry digitized information from sender to receiver. The ability of the antenna system to meet stringent requirements on coverage zones, multiple users, and reliability will play an important part in the overall multiple access communication system. This paper will describe the configuration of a multibeam conformal phased array antenna and the individual microwave integrated components incoporated into this antenna system.
Author

N86-23053# Sandia National Labs., Albuquerque, N. Mex.
DESIGN CONSIDERATIONS FOR LARGE PHOTOVOLTAIC SYSTEMS
G. J. JONES, H. N. POST, J. W. STEVENS, and T. S. KEY 1985 19 p Presented at the 18th IEEE Photovoltaic Specialists Conference, Las Vegas, Nev., 21 Oct. 1985
(Contract DE-AC04-76DP-00789)
(DE86-002125; SAND-85-1189C; CONF-851043-14) Avail: NTIS HC A02/MF A01

The design of large photovoltaic systems has been the subject of many years of system and subsystem research. This research information can now be supplemented with data from numerous operating systems ranging in size from kilowatts to multi megawatts. The compilation of all results verify that the design process for the photovoltaic system is simple. Construction should be based on good engineering practice coupled with PV specific hardware and a few PV specific design guidelines. These guidelines include considerations related to the selection of collector type, hardware specification, array field configuration, and system installation and checkout. This paper presents a discussion of these photovoltaic specific design considerations.
DOE

N86-24877*# TRW Space Technology Labs., Redondo Beach, Calif. Federal Systems Div.
SATELLITE VOICE BROADCAST SYSTEM STUDY, VOLUME 2 Technical Report, 11 Apr. 1984 - 11 Jul. 1985
M. HORSTEIN Jul. 1985 335 p refs 3 Vol.
(Contract NAS3-24232)
(NASA-CR-174905; NAS 1.26:174905) Avail: NTIS HC A15/MF A01 CSCL 17B

This study investigates the feasibility of providing Voice of America (VOA) broadcasts by satellite relay, rather than via terrestrial relay stations. Satellite voice broadcast systems are described for three different frequency bands: HF (26 MHz), VHF (68 MHz), and L-band (1.5 GHz). The geographical areas of interest at HF and L-band include all major land masses worldwide with the exception of the U.S., Canada, and Australia. Geostationary satellite configurations are considered for both frequency bands. In addition, a system of subsynchronous, circular satellites with an orbit period of 8 hours is developed for the HF band. VHF broadcasts, which are confined to the Soviet Union, are provied by a system of Molniya satellites. Satellites intended for HF or VHF broadcastinbg are extremely large and heavy. Satellite designs presented here are limited in size and weight to the capability of the STS/Centaur launch vehicle combination. Even so, at HF it would take 47 geostationary satellites or 20 satellites in 8-hour orbits to fully satisfy the voice-channel requirements of the broadcast schedule provided by VOA. On the other hand, three Molniya satellites suffice for the geographically restricted schedule at VHF. At L-band, only four geostationary satellites are needed to meet the requirements of the complete broadcast schedule. Moreover, these satellites are comparable in size and weight to current satellites designed for direct broadcast of video program material.
Author

N86-24878*# TRW, Inc., Redondo Beach, Calif.
SATELLITE VOICE BROADCAST SYSTEM STUDY. VOLUME 1: EXECUTIVE SUMMARY Contractor Report, 11 Apr. 1984 - 11 Jul. 1985
M. HORSTEIN Jul. 1985 46 p , 1-45 NOV.
(Contract NAS3-24232)
(NASA-CR-174904; NAS 1.26:174904) Avail: NTIS HC A03/MF A01 CSCL 17B

The feasibility of providing Voice of America (VOA) broadcasts by satellite relay was investigated. Satellite voice broadcast systems are described for three different frequency bands: HF, FHV, and L-band. Geostationary satellite configurations are considered for both frequency bands. A system of subsynchronous, circular satellites with an orbit period of 8 hours was developed for the HF band. The VHF broadcasts are provided by a system of Molniya satellites. The satellite designs are limited in size and weight to the capability of the STS/Centaur launch vehicle combination. At L-band, only four geostationary satellites are needed to meet the requirements of the complete broadcast schedule. These satellites are comparable in size and weight to current satellites designed for the direct broadcast of video program material.
Author

N86-25680# Lawrence Livermore National Lab., Calif.
BEHAVIOR OF VERY LARGE SHORT PULSE ANTENNAS. REVISION 1
H. M. BUETTNER and A. J. SPERO Oct. 1985 72 p
(Contract W-7405-ENG-48)
(DE86-004180; UCID-20080-REV-1) Avail: NTIS HC A04/MF A01

The electromagnetic behavior of a pulsed array of radiating elements can exhibit marked differences from standard continuous wave (CW) behavior when the physical size of the array, D, exceeds the physical pulse length, cT (speed of light times pulse duration). Herein is presented a simple analytical model and the results of computer code calculations which explain and illustrate those differences. Further elaborated is the behavior of these very large transient antennas (VLTA) using computer codes to illustrate the effects on the radiation pattern when the radiators exhibit randomness of turn-on time, phase, or amplitude. Results show that the physical space into which a linear VLTA radiates can significantly be divided into two regions by the off-axis angle THETA(sub T) identical to arcsin (cT/D). Within the near-axis region (THETA THETA(sub T)), the behavior of a coherently radiating (pulses simultaneously initiated) array is dominated by a CW antenna pattern. That is, the lobe structure found in the energy-deposition pattern is essentially that of the CW case. In the far-axis region (THETA THETA (sub T) the behavior of acoherently radiating array is dominated by transient effects. No CW-like pattern is seen; instead the energy-deposition pattern is roughly prop ortional to 1/sin (sq) THETA with only a suggestion of lobes.
DOE

N86-25689*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
SYSTEM ENGINEERING STUDY OF ELECTRODYNAMIC TETHER AS A SPACEBORNE GENERATOR AND RADIATOR OF ELECTROMAGNETIC WAVES IN THE ULF/ELF FREQUENCY BAND Semiannual Report, 1 Sep. 1985 - 28 Feb. 1986
R. D. ESTES, M. D. GROSSI, and E. C. LORENZINI Mar. 1986 48 p refs
(Contract NAG8-551)
(NASA-CR-176749; NAS 1.26:176749; SAR-1) Avail: NTIS HC A03/MF A01 CSCL 20N

The transmission and generation by orbiting tethered satellite systems of information carrying electromagnetic waves in the ULF/ELF frequency band to the Earth at suitably high signal intensities was examined and the system maintaining these intensities in their orbits for long periods of time without excessive onboard power requirements was investigated. The injection quantity power into electromagnetic waves as a function of system parameters such as tether length and orbital height was estimated. The basic equations needed to evaluate alternataing current tethered systems for external energy requirements are presented.

The energy equations to tethered systems with various lengths, tether resistances, and radiation resistances, operating at different current values are applied. Radiation resistance as a function of tether length and orbital height is discussed. It is found that ULF/ELF continuously radiating systems could be maintained in orbit with moderate power requirements. The effect of tether length on the power going into electromagnetic waves and whether a single or dual tether system is preferable for the self-driven mode is discussed. It is concluded that the single tether system is preferable over the dual system. E.A.K.

N86-26711# AEG-Telefunken, Wedel (West Germany).
GROWTH CAPABILITIES OF EUROPEAN RETRACTABLE SOLAR ARRAYS Final Report
G. BEHRENS Paris, France ESA Jun. 1985 89 p
(Contract ESTEC-5554/83-NL-PB(SC))
(ESA-CR(P)-2141; ETN-86-96870) Avail: NTIS HC A05/MF A01

The growth capabilities of the Advanced Rigid Array, Rigid Solar Generator, L-Sat solar array, SOLA solar array, Space Telescope solar array, and the Ultralight Panel array were assessed. Capabilities of up to 18kW are needed for the NASA manned space station. The assessment shows that each of the arrays can reach the required power range, but without taking economic factors into account, and given that only the existing application was considered, it is not possible to recommend any particular concept. ESA

N86-27658*# Contraves Italiana, Rome.
COMLINK PROPOSAL FOR FUTURE MISSIONS OF TETHERED SATELLITE
F. SCIARRINO *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 387-398 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

The quality of the communications links between satellites was tested. The interaction between the VLF and ELF waves, generated by the conducting tether, and the SHF and YHF electromagnetic waves, generated by the 20/30 GHz transmitters were investigated. The ionspheric electron density irregularities was measured by means of phase-coherent RF transmission between the two vehicles. The motion of the tethered satellite was observed through the Doppler link established between the shuttle and the satellite. The technology and deployment of spaceborne antennas of large diameter was tested. E.R.

N86-28414*# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. Fisica Spazio Interplanetario.
ELECTRODYNAMIC INTERACTIONS
M. DOBROWOLNY *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 153-160 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

The electrodynamic interaction of long metallic tethers with the ionosphere is introduced. Due to the tether's motion across the Earth's field, a polarization electric field is generated along the tether. In a system like the Tethered Satellite System (TSS) where the tether is coated with dielectric and the electrical contact is between its two terminations and the ionosphere, the upper end termination will collect electrons and, in a passive system, the lower end termination will collect ions. Space charge regions will develop around the two terminations of the system, which can be at considerable potential with respect to the unperturbed ionospheric plasma and the current in the tether will be most significantly determined by local processes in such space charge regions. A qualitative view of the global perturbation induced by TSS in the ionosphere is outlined. One of the applications of electrodynamic tethers is that of using them as low frequency wave generators to communicate to the Earth. This application is briefly discussed. An equivalent circuit of the tether system is described. The basic equation of the circuit is given. E.R.

N86-28973*# Martin Marietta Corp., Denver, Colo.
NEAR-FIELD TESTING OF THE 15-METER MODEL OF THE HOOP COLUMN ANTENNA. VOLUME 3: NEAR- AND FAR-FIELD PLOTS FOR THE JPL FEED
J. HOOVER, N. KEFAUVER, T. CENCICH, and J. OSBORN Mar. 1986 147 p
(Contract NAS1-18016)
(NASA-CR-178061; NAS 1.26:178061; MCR-85-640-VOL-3)
Avail: NTIS HC A07/MF A01 CSCL 09C

Technical results from near-field testing of the 15-meter model of the hoop column antenna at the Martin Marietta Denver Aerospace facility are discussed. The antenna consists of a deployable central column and a 15 meter hoop, stiffened by cables into a structure with a high tolerance repeatable surface and offset feed location. The surface has been configured to have four offset parabolic apertures, each about 6 meters in diameter, and is made of gold plated molybdenum wire mesh. Pattern measurements were made with feed system radiating at frequencies of 7.73, 11.60, 2.27, 2.225, and 4.26 (all in GHz). This report (Volume 3) gives the detailed patterns measured with the JPL feed (2.225 GHz). Volume 1 covers the testing from an overall viewpoint and contains information of generalized interest for testing large antennas, including the deployment of the antenna in the Martin Facility and the measurements to determine mechanical stability and trueness of the reflector surface, the test program outline, and a synopsis of antenna electromagnetic performance. A detailed listing of the antenna patterns for the LaRC feeds (7.3, 11.60, 2.27, and 4.26 GHz) are given in Volume 2 of this report. Author

N86-29115*# Martin Marietta Corp., Denver, Colo.
NEAR-FIELD TESTING OF THE 15-METER MODEL OF THE HOOP COLUMN ANTENNA Final Report
J. HOOVER, N. KEFAUVER, T. CENCICH, J. OSBORN, and J. OSMANSKI Mar. 1986 123 p
(Contract NAS1-18016)
(NASA-CR-178059; NAS 1.26:178059; MCR-85-640) Avail: NTIS HC A06/MF A01 CSCL 20N

The technical results from near-field testing of the 15-meter model of the hoop column antenna at the Martin Marietta Denver Aerospace facility are documented. The antenna consists of a deployable central column and a 15 meter hoop, stiffened by cables into a structure with a high tolerance repeatable surface and offset feed location. The surface has been configured to have four offset parabolic apertures, each about 6 meters in diameter, and is made of gold plated molybdenum wire mesh. Pattern measurements were made with feed systems radiating at frequencies of 7.73, 11.60, 2.27, 2.225, and 4.26 (all in GHz). This report (Volume 1) covers the testing from an overall viewpoint and contains information of generalized interest for testing large antennas. This volume discusses the deployment of the antenna in the Martin Facility and the measurements to determine mechanical stability and trueness of the reflector surface, gives the test program outline, and gives a synopsis of antenna electromagnetic performance. Three techniques for measuring surface mechanical tolerances were used (theodolites, metric cameras, and near-field phase), but only the near-field phase approach is included. The report also includes an error analysis. A detailed listing of the antenna patterns are provided for the 2.225 Ghz feed in Volume 3 of this report, and for all other feeds in Volume 2. Author

N86-29877*# Martin Marietta Aerospace, Denver, Colo.
NEAR-FIELD TESTING OF THE 15-METER MODEL OF THE HOOP COLUMN ANTENNA. VOLUME 2: NEAR- AND FAR-FIELD PLOTS FOR THE LARC FEEDS
J. HOOVER, N. KEFAUVER, T. CENCICH, and J. OSBORN Mar. 1986 282 p
(Contract NAS1-18016)
(NASA-CR-178060; NAS 1.26:178060; MCR-85-640-VOL-2)
Avail: NTIS HC A13/MF A01 CSCL 22B

The technical results from near-field testing of the 15-meter model of the hoop column antenna at the Martin Marietta Denver

Aerospace facility are described. The antenna consists of a deployable central column and a 15-meter hoop, stiffened by cable into a structure with a high tolerance repeatable surface and offset feed location. The surface has been configured to have four offset parabolic apertures, each about 6 meters in diameter, and is made of gold plated molybdenum wire mesh. Pattern measurements were made with feed systems radiating at frequencies of 7.73, 11.60, 2.27, 2.225, and 4.26 (all in GHz). This report (Volume II) gives the detailed patterns measured with the LaRC feeds (7.73, 11.60, 2.27, and 4.26 GHz). Volume I covers the testing from an overall viewpoint and contains information of generalized interest for testing large antennas, including the deployment of the antenna in the Martin Facility and the measurements to determine mechanical stability and trueness of the reflector surface, the test program outline, and a synopsis of antenna electromagnetic performance. A detailed listing of the antenna patterns are provided for the 2.225 Ghz feed in Volume III of this report. Author

N86-29893# Toronto Univ. (Ontario). Dept. of Electrical Engineering.

CHARGE ACCUMULATION AND ARC DISCHARGES ON SPACECRAFT MATERIALS AND COMPONENTS Final Report, 1 Sep. 1984 - 31 Aug. 1985

K. G. BALMAIN 11 Nov. 1985 62 p

(Contract AF-AFOSR-0342-84)

(AD-A166216; AFOSR-86-0057TR) Avail: NTIS HC A04/MF A01 CSCL 22B

A study of arc discharge strength was carried out, emphasizing its variation with the thickness of the dielectric-sheet specimens which had been exposed to an incident 20 keV electron beam at a current density of a thickness at which the peak current and the energy released into a load resistor are maximized. The addition of a low-energy ion beam was found to reduce discharge strength without significantly altering thickness-scaling. Also, experimental evidence was presented for a new effect called the ion spot phenomenon in which the incident ions are focussed into a central spot which then glows due to electron-impact luminescence. The first stage in the analysis of the ion spot phenomenon has been carried out and is described in this report. A two-dimensional analysis reveals complex ion trajectories which produce not only a strip (equivalent to a spot) of ion deposition, but are also such as to produce a spot with very sharply defined edges, just as observed experimentally. As for the spacecraft-charging experimental facility, a chamber capable of holding specimens up to 30 cm diameter has been completed. Arc discharges of 700 A peak have been recorded for the largest specimens and a system for making surface potential measurements has been tested.

GRA

N86-30590*# Chicago Univ., Ill. Lab. for Astrophysics and Space Research.

A NEW INSTRUMENT TO MEASURE CHARGED AND NEUTRAL COMETARY DUST PARTICLES AT LOW AND HIGH IMPACT VELOCITIES

T. ECONOMON, J. A. SIMPSON, and A. J. TUZZOLINO *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 54-55 1986 refs

Avail: NTIS HC A06/MF A01 CSCL 03B

A new class of dust particle detector, the PVDF dust detector, was designed for space missions such as the Halley Comet missions where the particle impact velocity is very high. It is demonstrated that this same PVDF detector (operating in a different mode) also has the capability of detecting dust particles having low velocity (approx. 100 m/s). This low velocity detection capability is extremely important in terms of planned missions requiring measurement of low velocity dust particles such as comet rendezvous missions. An additional detecting element (charge induction cylinder) was also developed which, when combined with a PVDF detector, yields a system which will measure the charge (magnitude and sign) carried by a cometary particle as well as the particle velocity and mass for impact velocities in the range 100 to 500 m/s. Since the cylinder-PVDF detector system has a relatively small geometry factors, an array of PVDF detectors was included having a total sensing area of 0.1 sq m for measurements in regions of space where the dust flux is expected to be low. The characteristics of the detectors in this array have been chosen to provide optimum mass sensitivity for both low-velocity cometary dust as well as high-velocity asteroid associated and interplanetary dust. Author

N86-30796# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.

DESIGN AND DEVELOPMENT OF THE ADVANCED RIGID ARRAY (ARA) SOLAR PANEL

R. W. H. HORSSELENBERG *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 319-328 Feb. 1986

Avail: NTIS HC A16/MF A01

The Advanced Rigid Array panel technologies are summarized: specific weight is less than 1.2 kg/sqm; can survive extreme thermal cycling (plus 80 to minus 180 C); excellent flatness and dimensional stability; extremely high stiffness properties due to application of GY-70 carbon fiber; high satellite interface flexibility; high panel sizing flexibility; and simple and low cost production. Developments include the establishment of panel technologies to obtain specific weights below 0.8 kg/sqm via open lay-up CFRP facesheet technology. ESA

N86-30802# Tri-Con Associates, Inc., Cambridge, Mass.

DESIGN, FABRICATE AND TEST SPACECRAFT AUTOMATIC ACTIVE DISCHARGE SYSTEM (SAADS) Final Report, 20 Jul. 1983 - 15 Jun. 1985

R. S. HILLS 25 Sep. 1985 18 p

(Contract F19628-83-C-0153)

(AD-A166559; C-214; AFGL-TR-85-0236) Avail: NTIS HC A02/MF A01 CSCL 22B

The objective of this contract is the design, fabrication, and testing of a Spacecraft Automatic Active Discharge System (SAADS) which will attempt to automatically control and dissipate the vehicle charge as a function of natural or induced disturbances in space. A microprocessor based controller will monitor and manipulate data from a Proton Electrostatic Analyzer (ESA) to determine if the vehicle charge is greater than a predetermined value and then activate a Plasma Source to discharge the vehicle. The plasma source short circuits the charge. This equipment is to be flown as part of the BERT I payload to demonstrate the feasibility of the system for eventual use in a satellite in a true space environment. GRA

N86-31113# Oak Ridge National Lab., Tenn.

DEVELOPMENT OF A SIMULATION CODE FOR A LATENT HEAT THERMAL ENERGY STORAGE SYSTEM IN A SPACE STATION

A. D. SOLOMON, M. D. MORRIS, J. MARTIN, and M. OLSZEWSKI Apr. 1986 48 p

(Contract DE-AC05-84OR-21400)

(DE86-010070; ORNL-6213) Avail: NTIS HC A03/MF A01

A conceptual design of a space station power system based on a Brayton cycle and solar powered has been developed. A key part of such a system is the thermal energy storage module, which is of crucial importance during periods of darkness. We have developed a simulation code for one possible storage configuration. In this report, we describe the considerations entering into the code development, and some results obtained thus far.

DOE

N86-31997# Societe Nationale Industrielle Aerospatiale, Cannes (France).

HIGH POWER RIGID SOLAR ARRAY

M. A. ZILIANI and L. PELENC 1986 7 p

(SNIAS-861-440-110; ETN-86-97618) Avail: NTIS HC A02/MF A01

The design of a solar array providing 30 kW is described. Main specifications are compatibility with the European Columbus platform and resource module, low life cycle cost, reliability, multideployment-retraction ability and low development risk. The

design is based on interchangeable rigid panels with silicon cells and proved pantograph mechanisms. The advantages of this concept include modularity at elementary panel (0.5 kW) level, capability of providing power while partially retracted, and of withstanding high levels of in-orbit loads. ESA

N86-31998# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
HIGH POWER SOLAR ARRAY (HPSA) STUDY Final Report
G. J. HEGEMANS Paris ESA Jun. 1985 110 p
(Contract ESTEC-6063/84-NL-PB(SC))
(FOK-TR-R-85-068; ESA-CR(P)-2182; ETN-86-97795) Avail: NTIS HC A06/MF A01

The design of a 30 kW planar Si-cell solar array for space shuttle payloads along with a GaAs-concentrator array are presented. Both arrays consist of blankets supported by a central, coplanar telescopic mast. Analysis results describing the array performances are summarized. A design and development philosophy is presented, critical design areas are pinpointed, and descoping/growth capability, orbital replacement units, and extravehicular servicing are discussed. ESA

N86-32517# MATRA Espace, Toulouse (France). Direction Etudes Systemes Spatiaux et Charges Utiles.
ESABASE EXTENSION TO SPACECRAFT CHARGING Final Report
M. FREZET Paris ESA 17 Jun. 1986 125 p
(Contract ESTEC-3-5632/83-NL-PP)
(MATRA-CMT-TS101/RT/16.85; ESA-CR(P)-2191; ETN-86-97792) Avail: NTIS HC A06/MF A01

A system level tool, ESABASE/CHARGING, to simulate spacecraft charging in space conditions (geosynchronous) and test tank environment is described. The software results from the coupling of NASCAP with ESABASE/MATVIEW. It offers an integrated framework with automatic file management. Up to 30 different files are generated during a typical simulation. A high-level input langauge is automatically interpreted to generate the rigid NASCAP inputs. A 3-D preprocessor sets up the NASCAP model. A fully 3-D postprocessor allows the visualization of user-defined parameters for a selected cycle on the spacecraft. The 3-D postprocessor is easy to use and fast. Improved NASCAP auxiliary codes plot colored equipotentials or various graphics with UDISP. ESA

07

ADVANCED MATERIALS

Includes matrix composites, polyimide films, thermal control coatings, bonding agents, antenna components, manufacturing techniques, and space environmental effects on materials.

A86-30323
THE SHUTTLE GLOW AS AN INDICATOR OF MATERIAL CHANGES IN SPACE
B. D. GREEN (Physical Sciences, Inc., Andover, MA) and E. MURAD (USAF, Geophysics Laboratory, Bedford, MA) Planetary and Space Science (ISSN 0032-0633), vol. 34, Feb. 1986, p. 219-224. refs
(AD-A167300; AFGL-TR-86-0082)

Observations of the glow occurring above the spacecraft surfaces and the theories used to explain this phenomena are reviewed. The interaction between the energetic ambient flux and the Shuttle near-field environment, and the reactions of energetic ambient ions and neutrals with the Shuttle surface are examined. It is observed that the reactions which produce the glow affect the composition and properties of the surface and alter the thermal, structural, or electrical characteristics. The glow also affects the ability of the astronauts to make remote observations from the spacecraft and causes material erosion. The spectral emissions that could arise from the surface reaction products are analyzed. It is concluded that the Shuttle glow is observed only on the surface and in the ram direction, and the composition of the surface material and the interaction of this material with the ambient at orbital velocities produces the emission. I.F.

A86-32406
SPACE ENVIRONMENT EFFECTS ON SPACECRAFT SURFACE MATERIALS
H. K. A. KAN (Aerospace Corp., El Segundo, CA) IN: Radiation effects in optical materials; Proceedings of the Thirteenth Critical Reviews of Technology Conference, Albuquerque, NM, March 6, 7, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 164-179. Research supported by the Aerospace Corp. refs

A review is given of the effect of the space environment on the external surfaces of satellites. The early development of thermal control materials in the 1960's and the 1970's is summarized. Selected recent results, based on flight experiments from the SCATHA satellite (P78-2) of the Space Test Program and the Space Shuttle, are reviewed along with laboratory experiments designed to understand the often unexpected results of the flight experiments. The topics include long-term stability of thermal control materials, contamination, spacecraft charging, and the effect of oxygen atoms on materials. Several areas of future research are proposed. Author

A86-32917#
APPLICATION AND POTENTIAL FUTURE OF ADVANCED COMPOSITES IN SPACE
W. A. SIGUR (Martin Marietta Corp., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 33 p. refs

Historical composite spacecraft systems are reviewed, and the performance of advanced composites in space is discussed. The advanced composites of greatest usefulness in space applications are described, and the specific applications of such composites in various historical space missions are summarized. Pertinent space applications of advanced composites over the next 30 years are given, stating what particular functions composites are to be used for in various missions. Developments and trends in reinforcements, matrix materials, and advanced composite systems which may be instrumental in future spacecraft composites are listed, and unique manufacturing and design concepts which should contribute to potential composite usage are mentioned. C.D.

A86-32977#
REACTION OF HIGH-VELOCITY ATOMIC OXYGEN WITH CARBON
G. S. ARNOLD and D. R. PEPLINKSI (Aerospace Corp., Chemistry and Physics Laboratory, El Segundo, CA) AIAA Journal (ISSN 0001-1452), vol. 24, April 1986, p. 673-677. Research supported by the Aerospace Corp. Previously cited in issue 06, p. 741, Accession no. A84-18159. refs

A86-39951#
LONG-TERM PERFORMANCE OF THERMAL CONTROL COATINGS AT GEOSYNCHRONOUS ALTITUDE
D. F. HALL and A. A. FOTE (Aerospace Corp., El Segundo, CA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 11 p. refs
(Contract F04701-85-C-0086)
(AIAA PAPER 86-1356)

Flight measurements on 16 thermal control coating materials over 2200 days at geosynchronous altitude are reported. Fused-silica second surface mirrors and polished metals are much more stable in space than the other sample types. Two types of transparent conductive coatings degrade during the first year. Metallized Teflon FEP and Kapton degrade over a long time period, probably because of bombardment by ambient protons. The backing material on quartz fabrics influences their degradation.

3M 401C10 black paint bleaches slowly on orbit. The time dependence of the degradation of several of these samples is well described by physical models of the degradation processes.
Author

A86-40371
CONTINUOUS FORMING OF THIN-WALLED CFRP PIPES FOR LARGE-SPACE STRUCTURE
T. WATANABE, T. SUGANO, and K. MURAYAMA (Mitsubishi Electric Co., Materials Laboratory, Sagamihara, Japan) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 505-510. Research sponsored by the Agency of Industrial Science and Technology.

A high efficiency continuous forming process for long and thin-walled CFRP pipes has been developed. The pipe will be applied to future large-scale space structures. An original manufacturing system, both process and equipment, is described. The essential working conditions of the pultrusion process through fabrication and quality evaluation of the products are presented. A useful method and the appropriate cure condition for the raw material are described. It was confirmed that the pultruded CFRP pipe had qualities equivalent to those obtained by the conventional batch method.
Author

A86-40378
THE PRODUCTION AND PROPERTIES OF COMPOSITE MATERIALS WITH LIGHT ALLOY MATRICES REINFORCED WITH CONTINUOUS FIBERS (C, SIC) [ELABORATION ET PROPRIETES DE MATERIAUX COMPOSITES A MATRICES D'ALLIAGELERERS REINFORCEES DE FIBRES CONTINUES /C, SIC/]
P. MACHETO (Aerospatiale, Division Systemes Balistiques et Spatiaux, Les Mureaux, France) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 616-622. In French. refs

Solid phase manufacturing processes used for metal matrix composites (MMC) are briefly described, along with the mechanical properties of the resulting materials. Attention is focused on carbon-aluminum (C/Al) and silicon carbide-aluminum (SiC/Al) MMCs, wherein Al forms the matrix for the C and SiC fibers. Metallized tapes or cloths of the reinforcing fibers are laid in the mold and then hot pressed with the Al matrix material at an atmospheric pressure of 150-250 bars and a 500-600 C temperature. The materials are then quenched under pressure. The temperature-pressure-time triplet determines the quality of the resulting materials. Three-point bending tests have shown that the fatigue resistance of the C/Al MMCs have remained the same at temperatures from 20-300 C due to the high ductility of the Al matrix. Samples of SiC/Al have exhibited as high a stiffness as the C/Al materials. The C/Al MMCs eventually crack from fiber/matrix separation, while the SiC/Al MMCs fail due to fiber breakage. Finally, the low coefficients of thermal expansion of both materials commends then as candidates for tests in large space structures.
M.S.K.

A86-40384
MAGNESIUM MATRIX COMPOSITE MATERIALS PROCESSING AND APPLICATIONS
O. REMONDIERE, R. PAILLER (CNRS, Laboratoire de Chimie du Solide, Talence, France), A. MAMODE, and PH. ROY (CNES, Toulouse, France) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 732-737. CNES-supported research. refs

Carbon-magnesium composite materials exhibit mechanical and thermal properties which make them suitable for large space structure applications in which a high dimensional stability is required. C/Mg composite materials are processed according to either vapor or liquid phase techniques. An analysis of the most recent techniques is given, based on laboratory experiments.
Author

A86-40487
CARBON FIBRES AND THEIR COMPOSITES
E. FITZER, ED. (Karlsruhe, Universitaet, West Germany) Berlin and New York, Springer-Verlag, 1985, 307 p. For individual items see A86-40488 to A86-40499.

The present conference considers topics encompassing the fields of advanced composite reinforcing fibers, polymeric matrices, fabrication and design methodologies for carbon fiber-reinforced composites (CFRPs), the testing and fracture behavior of CFRPs, CFRP applications in aerospace, and the R&D activities in carbon fiber production of Brazil, India, China, and South Korea. Specific discussions are presented concerning the effect of matrix resin choice on prepreg processing, the development of thermosetting polyimide matrix resins, autoclave compression molding, design preparations for large space structures, CFRP testing and properties optimization, industrial and marine applications of carbon fiber reinforcements, and biomedical applications of CFRP. O.C.

A86-40495
AUTOCLAVE, COMPRESSION MOULDING
K. BRUNSCH (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 149-158.

Autoclave and compression molding are well-known technologies in use for the fabrication of fiber composite structures. This paper presents data gathered with autoclave curing of extremely thin, high modulus carbon fiber-composite (CFC) face skins for space structures, autoclave-curing of thickness tapered high tensile CFC skin of an aircraft taileron, press curing of thick high tensile strength CFC rotor hub components, and the use of an oven for vacuum bag curing.
Author

A86-40498
EXPERIENCES IN FRG IN AEROSPACE APPLICATION
K. BRUNSCH (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 206-228.

Attention is given to the experience gained in West Germany to date with CFRPs' fiber, matrix resin, and fiber-resin interface characteristics. Attention is given to space structures applications such as the Intelsat V series satellites' solar cell array structure, as well as the Tornado fighter aircraft's taileron, a technology development CFRP fighter cockpit, and helicopter rotor blades and driveshafts. Also noted are recent advancements in CFRP fabrication and quality assurance techniques.
O.C.

A86-40503
CONTINUOUS FIBER COMPOSITE HOOPS
R. R. VARIN (Varinit Corp., Greenville, SC) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 2-1 to 2-3.

Low-cost, low-weight fiber-reinforced hoops up to 12 feet in diameter have been developed as reinforcement for space

assemblies, rocket casings, tanks, fly wheels, etc. Their properties are described. Author

A86-40530*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE THERMAL AND MECHANICAL STABILITY OF COMPOSITE MATERIALS FOR SPACE STRUCTURES
S. S. TOMPKINS, G. F. SYKES, and D. E. BOWLES (NASA, Langley Research Center, Hampton, VA) ASM, ASME, IEEE, et al., Conference and Exposition on Space Tech, Anaheim, CA, Sept. 23-25, 1985, Paper. 19 p. refs

A continuing research objective of the National Aeronautical and Space Administration (NASA) is to develop advanced composite materials for space structures. The thrust of this research is to gain fundamental understanding of the performance of advanced composites in the space environment. The emphasis has been to identify and model changes in the thermal-physical properties due to induced damage and develop improved materials. Author

A86-40594#
HIGH MODULUS COMPOSITE PROPERTIES
M. J. MICHNO, JR. (Union Carbide Corp., Specialty Polymers and Composites Div., Bound Brook, NJ) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 126-131. refs
(AIAA PAPER 86-1187)

Reliable component design with high modulus composites systems requires a mechanical and physical property data base, including both average property levels and a measure of property variability. Composite properties are presented for a number of Thornel Advanced Composites Systems based on P-55S, P-75S, and P-100S high modulus fibers. Specific composite laminate properties presented include: RT longitudinal tension and compression; RT transverse tension, longitudinal shear and flexural strength (RT to 300 F) and coefficients of thermal expansion valid for the temperature range of -200 F to +200 F. Thermomechanical stability data are presented for quasi-isotropic laminates cycled over the temperature range of -300 F to +200 F. Data indicate that the materials tested may be well suited to harsh thermal environments. However, the performance of candidate materials must be judged in terms of requirements for specific applications. Author

A86-41740#
EFFECT OF DEGRADATION OF MATERIAL PROPERTIES ON THE DYNAMIC RESPONSE OF LARGE SPACE STRUCTURES
S. KALYANASUNDARAM, J. D. LUTZ, W. E. HAISLER, and D. H. ALLEN (Texas A&M University, College Station) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 545-551) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 297-302. Previously cited in issue 13, p. 1855, Accession no. A85-30382. refs
(Contract F49620-83-C-0067)

A86-41750*# Auburn Univ., Ala.
ANALYSES OF SPACECRAFT POLYMERIC MATERIALS
S. D. WORLEY, A. T. FROMHOLD, K. DANESHVAR (Auburn University, AL), A. F. WHITAKER, S. A. LITTLE (NASA, Marshall Space Flight Center, Huntsville, AL) et al. Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 350-352. refs
(Contract NAS8-35914)

Partial analytical characterizations are made by four different techniques of three polymeric materials used in conjunction with the Space Telescope for samples flown on mission STS-8. The polymers were Tedlar, Kapton H, and Kapton F. The surfaces of the three polymers were attacked and oxidized by atomic oxygen, and fluorine is lost from the surface of Kapton F, largely due to displacement by atomic oxygen. O.C.

A86-45646
THE GERMAN PROGRAMME ON MATERIALS SCIENCE IN SPACE
W. STEINBORN (DFVLR, Cologne, West Germany) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 113-116.

Current West German experimental programs on materials processing in space are reviewed in relation to follow-on experiments in the Columbus segment of the Manned Space Station (MSS). Over 80 percent of the 78 projects active in 1985 were funded by institutions, and were in part dedicated to improving the quality and quantity of the materials processed. West Germany performed electrophoresis experiments on the Apollo-Soyuz mission, experiments with immiscible alloys on the SPAR rocket, and several experiments on the STS OSTA and Spacelab missions. All the previous experiments suffered from the short on-orbit stay and from a lack of continuous power supplies should the stays have been longer. The MSS will ameliorate these problems and access to experimental apparatus will be increased by the multi-user facility nature of the MSS. M.S.K.

A86-47337
SPACECRAFT MATERIALS TEST IN A CONTINUOUS, BROAD ENERGY-SPECTRUM ELECTRON BEAM
M. BLEZ, J. THAYER, and J. E. NANEVICZ (SRI International, Menlo Park, CA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 485-497. refs

The discharge behavior of several samples made of Kapton, a material used in spacecraft thermal control systems was studied under conditions of a simulated space environment, comparing the results of exposure to two types of electron beams. The first was a constant monoenergetic electron beam, used in past studies; the second was a continuous broad-energy-spectrum electron beam, generated by a novel multienergy multipactor electron gun. It has been found that the discharges produced by a multienergetic beam, which represents a more realistic environment situation, had longer (by a factor of 2) rise times than the discharges produced by a monoenergetic beam, indicating lower penetration efficiency by the multienergetic beam. However, while the samples exposed to a monoenergetic beam have stopped discharging after a few minutes, the same samples exposed to a multienergetic beam continued discharging indefinitely. The hitherto uncontrolled physical parameters, such as the manner of cleaning the sample and the production run of a sample, were found to influence the material response. I.S.

A86-47605
ENHANCEMENTS IN THE ROUTINE EVALUATION OF COMPOSITE AEROSPACE COMPONENTS USING A MICROPROCESSOR BASED EQUIPMENT
P. R. TEAGLE (Inspection Instruments (NDT), Ltd., Slough, England) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports . Duesseldorf, West Germany, Duesseldorfer Messegesellschaft mbH, 1985, 39 p.

The principles of operation and signal detection techniques used in NDT are outlined, and the use of computer-based technology in such methods is discussed. A computerized scanning frame, used to eliminate the operator variability in the transducer manipulation, is described together with a device that can evaluate and digitize analog signals from any test equipment. The device provides five independently selectable threshold levels for data analysis, which can be set at the amplitudes significant to the particular test. The application of the intelligent scanning equipment, used in conjunction with the data analyzer, to three types of ultrasonic tests and to mechanical impedance testing is described. I.S.

A86-49595#
THE AFML/LOCKHEED TEST METHOD FOR CHARACTERIZING MATERIAL OUTGASSING AND DEPOSITION KINETICS
J. W. GARRETT, A. P. M. GLASSFORD (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), and P. M. FALCO (USAF, Materials Laboratory, Wright-Patterson AFB, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p. refs
(AIAA PAPER 86-1279)

An improved test method to characterize the contamination potential of spacecraft materials has been developed. The test provides material outgassing and condensation kinetics data to support contamination modeling. The test apparatus includes four quartz-crystal microbalances controlled at temperatures between liquid nitrogen and 125 C, a mass spectrometer, and an effusion cell. The test method includes material sample requirements, the test procedure, and data presentation. Author

N86-22617# Societe Crouzet, Valence (France).
ADVANCED PRINTED WIRING BOARD (PWB) MATERIALS FOR SURFACE MOUNTED DEVICES IN AEROSPACE APPLICATIONS
G. MENOZZI *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 203-213 Nov. 1985 refs Sponsored by CNES
Avail: NTIS HC A13/MF A01

Multilayer thick film hybrid and printed wiring board technologies for leadless ceramic chip carriers (LCCC) were developed. Copper clad invar MLBs prove to be a viable solution for LCCC interconnects. The CIC core MLB offers advantages such as large size, both-side mounting, an inner thermal plane for thermal management, an easier rework process, and better vibration tolerance. One disadvantage is the weight. Thermal coefficient of expansion measurements and calculations offer a quick approach for material inspection and assembly evaluation. The thermal cycling test from minus 55 to plus 125 C widely used for evaluation programs consisting of several hundred cycles is not realistic for aerospace qualification tests. Author (ESA)

N86-22619# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
HIGH VOLTAGE POTTING FOR THE FAINT OBJECT CAMERA (FOC)
R. THOMAS *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 223-228 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

Potting the high voltage parts on the photon detector of the Faint Object Camera (FOC) for the Space Telescope is described. The detector is required to have very high gain to provide a logic level signal for digital processing. Gain is provided by an image intensifier and a video camera tube, the former operating at up to 42KV (normally at 38KV) and the latter in the range -6.5 to -12KV (normally -10KV). Experience in developing the detector (including catastrophic failures) shows that when high voltage circuits are potted it is essential to define and control potentials on all surfaces. It is strongly recommended that a dummy unit be potted with pressure and stress gages to determine the forces involved in curing and environmental test cycles. The application of partial discharge testing is essential for assemblies and desirable for past screening (cables, correction techniques at least). Potting should be under vacuum and scrupulous attention must be paid to cleanliness of surfaces to be potted and all containers and equipment used for priming and potting. Author (ESA)

N86-22620# Selenia S.p.A., Rome (Italy).
MEASUREMENT OF THE THERMO-OPTICAL PROPERTIES OF VARYING PAINT THICKNESS ON CARBON FIBER COMPOSITES IN SPACECRAFT STRUCTURES
M. GIOMMI, M. MARCHETTI (Rome Univ., Italy), G. SALZA, and P. TESTA (Rome Univ., Italy) *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 233-238 Nov. 1985 refs Sponsored by Max-Planck Inst.
Avail: NTIS HC A13/MF A01

Diffuse spectral reflectivity for solar radiation at normal incidence, spectral normal emissivity, and integrated normal emittance for PV 100 painted samples having different paint thickness and different (carbon fiber or non) substrates were measured. Results mainly for thickness 70 microns show high spectral reflectivity or low spectral absorption coefficient while spectral emissivity has medium-high values. Limited effect (order of 10%) of the texture and thickness are pointed out.
Author (ESA)

N86-22621# Centre National d'Etudes Spatiales, Toulouse (France).
NEW SPACE PAINTS
J. C. GUILLAUMON *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 239-243 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

White conductive paint with low solar absorptance (improvement of PCB-Z) (0.16 to 0.18); black conductive paint with low outgassing (improvement of PU1); white silicone paint with low solar absorptance (0.13); epoxy primer with low outgassing; and white conductive paint for launchers and aircraft were developed. Improvements under study are outlined. Author (ESA)

N86-22622# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Technologie Spatiale.
LONG TERM TESTS OF CONTAMINATED OPTICAL SOLAR REFLECTORS (OSRS) UNDER COMBINED ENVIRONMENT
J. MARCO and A. PAILLOUS *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 245-253 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

A simulation program for 5 yr in geosynchronous orbit was carried out on thermal control coatings. Conductive and nonconductive optical solar reflectors (OSR's) were subjected to various thickness (50 to 500A) of contamination deposited in-situ at the start of the test, and irradiated. The variation in solar absorptance at the end of the test is 3 to 4 times greater for the OSR's having received 500 A of the products outgassed from the RTV 566 adhesive. The test data show that contamination is the most likely cause of the excessive degradations observed on many geosynchronous satellites. Author (ESA)

N86-22623# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Materials Section.
THE DEGRADATION AND CONTAMINATION EXPERIMENT FLOWN ON THE FIRST EUROPEAN COMMUNICATION SATELLITE ECS-1: PRELIMINARY RESULTS ON CONTAMINATION
G. GOURMELON and P. JOLLET *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 255-258 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

An experiment on ECS-1 to study the in flight behavior of standard cerium doped optical solar reflectors is described. Three quartz crystal microbalances (QCMs) show a small increase of contamination certainly due to very light outgassing products at the beginning of the flight. During the first transfer orbit, a small reevaporation of these products occurred. At the firing of the apogee boost motor there is no detectable contamination on the QCMs. After 780 days in orbit QCM 1 and QCM 3 show the same level of contamination: 1200 ng/sqcm, comparable to the

value measured on SCATHA, considered as a clean satellite. On QCM 2 the level is 700 ng/sq cm and lower than QCM 1 and 3. A decrease which appears after 120 days in orbit cannot be explained. Author (ESA)

N86-22624# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SCANNING LASER ACOUSTIC MICROSCOPY APPLIED TO THE EVALUATION OF MATERIAL INTERCONNECTIONS
B. D. DUNN and D. S. COLLINS *In its* Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 263-269 Nov. 1985
Avail: NTIS HC A13/MF A01

The Scanning Laser Acoustic Microscope (SLAM) for the nondestructive inspection of materials and interconnections is introduced. The operational modes of the SLAM are illustrated during the assessment of spacecraft solar cell-to-silver interconnector weldments and electronic component chip solder-attachment to a ceramic carrier. Author (ESA)

N86-22626# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
ULTRAVIOLET RADIOMETERS
G. GOURMELON, H. LYALL (IRD, Newcastle upon Tyne, England), and R. FROUD (IRD, Newcastle upon Tyne, England) *In its* Proceedings of 3rd European Symposium on Spacecraft Materials Space Environment p 275-276 Nov. 1985
Avail: NTIS HC A13/MF A01

A radiometer to measure ultraviolet radiation in a series of bands between 180nm and 450nm in a space simulation system was developed. A single channel ultraviolet detector based on the multiband ultraviolet radiometers, but featuring a more robust construction for general use, was also developed. The wavelength coverage is from 250 to 400nm with excellent rejection of visible radiation, and good temperature stability. Detectors with filters to measure a narrow band within the ultraviolet can be supplied.
Author (ESA)

N86-22627# European Space Agency, Paris (France).
SPACE ENVIRONMENT SIMULATION TO TEST SATELLITE THERMAL CONTROL COATINGS, VOLUME 1
M. DUTAT, J. MARCO, and A. PAILLOUS Aug. 1985 149 p refs Transl. into ENGLISH of 'Essais de Simulation d'Environmentale Spatial sur Revetements de Controle Thermique de Satellites, Tome 1" Rept. CERT-4128-Vol-1 Centre d'Etudes et de Recherche de Toulouse, France Original language document was announced as N85-17012 3 Vol.
(ESA-TT-891-VOL-1; CERT-4128-VOL-1) Avail: NTIS HC A07/MF A01

Simultaneous irradiation of satellite thermal control coatings by electrons, protons, and ultraviolet radiation, simulating 5 yr in geostationary orbit, was carried out. A layer of contaminant, originating from adhesive RTV566 by molecular flux, was applied to samples under controlled conditions. Changes were followed by microbalances and by measurements of optical reflectance over the spectrum. Samples of optical solar reflector (OSR) show a 3 to 4-fold increase in solar absorptance when contaminated by a layer of thickness 0.00005g/sq cm. The test covered four types of OSR: aluminized kapton, ITO-covered FEP, thin aluminized kapton stuck on to thick kapton, white conductive paint PCB Z, and black paint Electrodag 501. The change in solar absorptance of the materials as a function of time in orbit was determined. The electrical conductivity of ITO-covered FEP was observed.
Author (ESA)

N86-24762# Martin Marietta Aerospace, Denver, Colo.
DAMPING CHARACTERISTICS OF METAL MATRIX COMPOSITES Quarterly Letter Report, 15 Sep. - 11 Dec. 1985
M. S. MISRA 11 Dec. 1985 6 p refs
(Contract N00014-85-C-0857)
(AD-A163569; MCR-85-721-ISSUE-1) Avail: NTIS HC A02/MF A01 CSCL 11D

Fiber reinforced metal matrix composites (MMC) are candidate structural materials for Large Space Structures because of their high specific stiffness, specific strength, and low coefficient of thermal expansion. In addition, MMC exhibits higher damping than structural alloys of aluminum or titanium, and the potential exists for designing MMC with predetermined damping, strength, and stiffness properties. In the present investigation P55/6061 Al composites with different fiber-fiber (consequently, fiber volume) spacing have been selected to study the damping characteristics.
GRA

N86-24880*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MEASUREMENT APPARATION AND PROCEDURE FOR THE DETERMINATION OF SURFACE EMISSIVITIES Patent Application
H. J. C. BLUME, inventor (to NASA) 3 Dec. 1985 27 p
(NASA-CASE-LAR-13455-1; NAS 1.71:LAR-13455-1; US-PATENT-APPL-SN-804040) Avail: NTIS HC A03/MF A01 CSCL 20N

A method and apparatus for independently determining the electromagnetic surface emissivity of a material is developed, which is particularly useful in the design of large deployable space antennas employing mesh membrane surfaces. The system is a closed one with respect to unwanted or uncorrelated radiation outside the system. The present embodiment comprises a radiometer connected to a horn antenna, a test section sealed to the horn antenna and a cryogenically cooled matched load (cryoload) exposed to the interior of the system. The material is enclosed in a convection test chamber within the test section, heated by convection within a test chamber and allowed to radiate within the system such that a component of the radiation energy of the material is measured by the radiometer in terms of brightness temperature. A matched load serves as the stabilized source of uncorrelated radiation within the system. The actual physical temperature of the material is also measured during the heating process with a thermometer. The difference in brightness temperature over a selected period of time when divided by the physical temperature over the same period of time is the emissivity of the material according to a derivation of the Raleigh - Jeans approximation for an ideal system free from all uncorrelated radiation. NASA

N86-26434*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OXIDATION PROTECTING COATINGS FOR POLYMERS Patent Application
J. S. SOVEY, inventor (to NASA), B. A. BANKS, inventor (to NASA), and M. J. MIRTICH, inventor (to NASA) 27 Feb. 1986 12 p Sponsored by NASA
(NASA-CASE-LEW-14072-3; NAS 1.71:LEW-14072-3; US-PATENT-APPL-SN-834977) Avail: NTIS HC A02/MF A01 CSCL 11B

A polymeric substrate is coated with a metal oxide film to provide oxidation protection in low Earth orbital environments. The film contains about four volume percent polymer to provide flexibility. NASA

N86-27376# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. fuer Technische Physik.
THE PERFORMANCE OF UNBONDED MOS2 FOR SPACE APPLICATIONS
V. BUCK *In* ESA Second European Space Mechanisms and Tribology Symposium p 155-159 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The performance of MoS2 as a dry lubricant in general is outlined and the advantages and disadvantages for space applications are reviewed. Knowledge in sputtering of MoS2 is discussed and the influence of preparation conditions on impurities or disorder of the films is assessed. Results showing correlations between H2O impurities in the plasma and structural parameters of the layers are given, and the importance of these effects is outlined. Considerations relating structural properties to tribological behavior are presented. ESA

N86-27377# Centre Suisse de Documentation dans le Domaine de la Microtechnique, Neuchatel. Dept. de Recherche et Developpement.
COATINGS AGAINST FRETTING
M. MAILLAT and H. E. HINTERMANN *In* ESA Second European Space Mechanisms and Tribology Symposium p 161-166 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Coatings and lubricants to protect aerospace mechanisms from wear and microweldings caused by fretting or reciprocal sliding were investigated. From the 144 tests performed, TiC, Tiodize and Adhesoil coatings show the best results under a high specific load; the best results are obtained with Rh + MoS2 coatings under low contact pressure against Be. ESA

N86-27378# European Space Tribology Lab., Risley (England).
SURFACE-TREATED TITANIUM ALLOY GEARS FOR SPACE MECHANISMS
R. A. ROWNTREE *In* ESA Second European Space Mechanisms and Tribology Symposium p 167-171 Dec. 1985 Sponsored by ESTEC
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The performance of surface treatments against adhesive wear (galling) on the alloy IMI 318 (Ti-6Al-4V) was tested using gears unlubricated in vacuum, in a four square rig. Gear performance was determined by life or number of tooth encounters before failure of the surface treatment rather than by wear depth. Conventional treatments such as nitriding or oxidation are found to offer limited improved gear life, above that of the untreated alloy. Boronizing gives the longest gear life but causes, during treatment, dimensional growth of the gears. Sputter-deposited coatings of TiN are poorly adherent to the substrate and give short lives. Arc-evaporated coatings of TiN give improved performance until coating fracture and subsequent galling of the titanium alloy occurs. ESA

N86-27379# Societe Nationale Industrielle Aerospatiale, Cannes (France).
USE OF MOS2 APPLIED BY PHYSICAL VAPOR DEPOSITION (PVD) ON SPACE MECHANISMS
J. F. PATIN, M. MAILLAT (Centre Suisse de Documentation dans le Domaine de la Microtechnique, Neuchatel.), and H. E. HINTERMANN *In* ESA Second European Space Mechanisms and Tribology Symposium p 173-176 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Satellite mechanisms using a solid lubricant film of MoS2 applied by physical vapor deposition or RF sputtering are described. This process satisfies space requirements because MoS2 has excellent friction properties in vacuum; nevertheless it is necessary to take into account moisture effects during ground tests. Parameters likely to influence the performances of lubricated mechanisms were studied on a pin on disk tribological test rig. Sputter coated MoS2 films are successfully used in the telecommunication satellite Arabsat, the observation satellite SPOT, and the television satellite TDF. Examples of lubricated mechanisms are antennas, rigid solar array deployment mechanisms, and flexible solar array box opening mechanisms. ESA

N86-28195*# College of William and Mary, Williamsburg, Va.
RADIATION EFFECTS ON HIGH PERFORMANCE POLYMERS Final Technical Report, 1 Jun. 1985 - 28 Feb. 1986
R. A. ORWOLL 1986 10 p
(Contract NAG1-593)
(NASA-CR-177191; NAS 1.26:177191) Avail: NTIS HC A02/MF A01 CSCL 11B

Polymer matrix materials are candidates for use in large space antennas and space platforms that may be deployed in geosynchronous orbit 22,500 miles above the Earth. A principal concern is the long term effects of an environment that is hostile to organic polymers, including high energy electromagnetic radiation, bombardment by charged particles, and large abrupt changes in temperature. Two polyarylene ethers which might be utilized as models for polymers in space applications were subjected to dosages of 70 keV electrons up to 3.4 x 10 to the 10th power rad. The irradiated films were then examined to determine the effects of the high-energy electrons. Author

N86-28633 Societe Nationale Industrielle Aerospatiale, Paris (France).
IMPACT OF AUTOMATION ON THE DESIGN OF CARBON FIBER OMEGA RIBS
CLARIOU, PEREZ, and PLAGNE 1986 16 p Presented at 3rd Intern. Conf. on Composite Structures, Paisley, Scotland, 9-11 Sep. 1985
(SNIAS-861-422-101; ETN-86-97158) Avail: NTIS HC A02

A method to reduce production costs and improve quality of solar array carbon fiber omega ribs was developed. An automatic laying process was designed, but the definition had to be modified, as the thickness was not constant throughout the section, and the laying was nonsymmetric. Steps decided to change the definition, meet the specifications with the same margins, requalify the new omegas at minimal cost, be sure of reproductibility and quality of the product, and sell it to the customer are outlined. The impact of industrial constraints on the definition and qualification process, and difficulties entailed by such a performance are discussed. ESA

N86-29989*# Boeing Aerospace Co., Seattle, Wash.
DEVELOPMENT OF COMPOSITE TUBE PROTECTIVE COATINGS Final Report
H. DURSCH and C. HENDRICKS Jul. 1986 109 p
(Contract NAS1-16854)
(NASA-CR-178116; NAS 1.26:178116; D180-29767-1) Avail: NTIS HC A06/MF A01 CSCL 11G

Protective coatings for graphite/epoxy (Gr/Ep) tubular structures proposed for the Space Station are evaluated. The program was divided into four parts; System Definition, Coating Concept Selection and Evaluation, Scale-up and Assembly, and Reporting. System Definition involved defining the structural and environmental properties required of the Gr/Ep tubes. The prepreg and ply sequence selected was a P75S/934 (O2, + or - 20, O2)sub s layup which meets the various structural requirements of the Space Station. Coating Concept and Selection comprised the main emphasis of the effort. Concepts for protectively coating the Gr/Ep tubes included the use of metal foil and electroplating. The program results demonstrated that both phosphoric and chromic acid anodized Al foil provided adequate adhesion to the Gr/Ep tubes and stability of optical properties when subjected to atomic oxygen and thermal cycling representative of the LEO environment. SiO2/Al coatings sputtered onto Al foils also resulted in an excellent protective coating. The electroplated Ni possessed unacceptable adhesion loss to the Gr/Ep tubes during atomic oxygen testing. Scale-Up and Assembly involved fabricating and wrapping 8-ft-long by 2-in-diameter Gr/EP tubes with chromic acid

anodized foil and delivering these tubes, along with representative Space Station erectable end fittings, to NASA LaRC. Author

N86-30595*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
EFFECTS OF THE LOW EARTH ORBITAL ENVIRONMENT ON SPACECRAFT MATERIALS Abstract Only
L. J. LEGER *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 67 1986
Avail: NTIS HC A06/MF A01 CSCL 03B

It is evident from space flights during the last three years that the low Earth orbital (LEO) environment interacts with spacecraft surfaces in significant ways. One manifestation of these interactions is recession of, in particular, organic-polymer-based surfaces presumably due to oxidation by atomic oxygen, the major component of the LEO environment. Three experiments have been conducted on Space Shuttle flights 5, 8 and 41-G to measure reaction rates and the effects of various parameters on reaction rates. Surface recession on these flights indicates reaction efficiencies approximately 3 x 10(-24) cu cm/atoms for unfilled organic polymers. Of the metals, silver and osmium are very reactive. Effects on spacecraft or experiment surfaces can be evaluated using the derived reaction efficiencies and a definition of the total exposure to atomic oxygen. This exposure is obtained using an ambient density model, solar activity data and spacecraft parameters of altitude, attitude and operational date. Oxygen flux on a given surface is obtained from the ambient density and spacecraft velocity and can then be integrated to provide the total exposure or fluence. Such information can be generated using simple computational programs and can be converted to various formats. Overall, the extent of damage is strongly dependent on the type of surface and total exposure time. Author

N86-30738*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
A SURVEY OF HANDLING QUALITIES CRITERIA AND THEIR APPLICATIONS TO HIGH PERFORMANCE AIRCRAFT Final Report
D. L. PEAHL, F. KOLKAILAH, and D. R. SANDLIN Jan. 1986 68 p
(Contract NCC2-338)
(NASA-CR-179654; NAS 1.26:179654) Avail: NTIS HC A04/MF A01 CSCL 01C

Various handling qualities criteria and their application to high performance aircraft including state-of-the-art and highly augmented aircraft were surveyed. Neal-Smith, Bandwidth, Equivalent Systems, and Military Specification 8785 criteria are applied to flight test data from aircraft such as the F-8 Digital Fly-By-Wire, the YF-12, and an Advanced Fighter Aircraft. Backgrounds and example applications of each criteria are given. The results show that the handling qualities criteria investigated can be applied to highly augmented aircraft with fairly good results in most cases; however, since no one method excelled, more than one criteria should be used whenever possible. Equivalent time delays appear to be the most frequent critical factor in determining pilot rating levels of highly augmented aircraft. Author

N86-30759# Fulmer Research Inst. Ltd., Stoke Poges (England).
THE APPLICATION OF COMPOSITES TO SPACE STRUCTURES: GUIDELINES ON IMPORTANT ASPECTS FOR THE DESIGNER
D. P. BASHFORD *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 9-16 Feb. 1986
Avail: NTIS HC A16/MF A01

Guidelines and surveys on the state of composites as structural aerospace materials were produced. The guidelines give a detailed background on composites for spacecraft and are intended for designers and engineers unfamiliar with composites. Topics covered include: selection of composite materials; aramid composites; prepreg and resin procurement specifications; nondestructive tests polymeric matrices; mechanical test methods for composites; joining techniques; and moisture absorption/thermal cycling response. ESA

N86-30760# Salford Univ. (England). Dept. of Pure and Applied Physics.
HYGROTHERMAL CHARACTERISTICS OF ANTENNA MATERIALS
J. W. ATKINSON, G. H. WOSTENHOLM, and B. YATES *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 17-24 Feb. 1986
Avail: NTIS HC A16/MF A01

Increases in mass resulting from the absorption of water by epoxy resins reinforced with Kevlar 49 and Nomex fibers are reported. The influence of relative humidity over the range 12% to 93% at 23 C was studied, along with the effects of fiber volume fraction and fiber type on the final moisture content of the systems. High volume fraction materials absorb less than low volume fraction materials. Nomex absorbs more moisture than Kevlar. The modified Boltzmann transport model proposed by Carter and Kibler (1978) gives a better description of the behavior than the classical Fickian model proposed by Shen and Springer (1976). Absorption from atmospheres at low humidities appears to be governed by different laws from those operating at intermediate and high humidities. ESA

N86-30761# National Engineering Lab., East Kilbride (Scotland).
FATIGUE AND DAMAGE IN FIBRE REINFORCED NYLON
W. S. CARSWELL *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 25-29 Feb. 1986 Sponsored by UK Dept. of Trade and Industry
Avail: NTIS HC A16/MF A01

Fatigue tests with a range of mean loads and at two temperatures were carried out on short glass-fiber nylon and short graphite-fiber reinforced nylon. Changes were monitored by noting the peak deflection. Range of deflections and the peak deflection increase, indicating a rotation of the hysteresis loop and creep in the direction of maximum load. The range of deflections at room temperature and at elevated temperature indicates endurance, although there are differences in performance at elevated temperature. The extent of such changes necessary for failure is obscure. ESA

N86-30762# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
THERMAL RESIDUAL STRESSES IN SYMMETRIC AND UNSYMMETRIC CARBON FIBER REINFORCED PLASTICS: SOME TENTATIVE WAYS OF EVALUATION
J. P. FAVRE *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 31-38 Feb. 1986
Avail: NTIS HC A16/MF A01

Effects of thermal stresses which develop during fabrication on the integrity of composites used in spacecraft are discussed. For an unsymmetric material, the result is a modification of the shape. In the simple case of a long and thin cross-ply specimen, residual stresses in the transverse plies can be deduced from reading the curvature. For a plate, the existence of several stable shapes according to the aspect ratio is verified. For the symmetric material, in-situ estimation of residual stress magnitude by X-ray diffraction using a metallic powder embedded between the plies is described. ESA

N86-30763# Atomic Energy Research Establishment, Harwell (England). Materials Development Div.
DYNAMIC MECHANICAL ANALYSIS AS AN AID TO THE CHARACTERIZATION OF COMPOSITE MATERIALS
D. H. BOWEN, R. DAVIDSON, R. J. LEE, and M. AGUIRRE *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 39-46 Feb. 1986
Avail: NTIS HC A16/MF A01

Dynamic mechanical analysis (DMA) was used to assess the thermal properties of polymeric materials and resin matrix carbon fiber composites. By considering the storage and loss moduli and damping as a function of temperature, information relating to the

nature, state of cure, and hysteretic characteristics of the matrix can be obtained. This information assists in the interpretation of the impact strengths and creep resistance of polymers and composites. Examples of the use of DMA in research and development programs with composite materials based on heat resistant thermoplastic (PES, PEI, PEEK) and thermosetting polymers (phenolics, bismaleimides and epoxides) are given. The factors and limitations affecting the quantitative stiffness measurements of orthotropic composite materials by DMA are discussed, specifically measurements on unidirectional carbon fiber reinforced polyether ether ketone. ESA

N86-30764# Southampton Univ. (England). Inst. of Sound and Vibration Damping.
DAMPING OF COMPOSITES
T. A. WILLWAY *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 47-52 Feb. 1986
Avail: NTIS HC A16/MF A01

Methods of predicting the damping characteristics of composite materials and the effects of various parameters on that damping are reviewed. Experimentally determined values of the damping of composite materials are given. ESA

N86-30767# Waldrich Siegen Werkzeugmaschinen G.m.b.H., Burbach (West Germany).
THEORETICAL AND EXPERIMENTAL BEHAVIOR OF CARBON FIBER REINFORCED PLASTICS UNDER MECHANICAL AND THERMAL LOAD
U. BIELING *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 71-78 Feb. 1986
Avail: NTIS HC A16/MF A01

Based on a fiber resin system for aerospace components, the linear and nonlinear stress-strain behavior of CRP laminates is investigated. Theoretical and experimental results correlate very well up to high loads by entering strain-dependent coefficients into the stiffness matrix. Approaches for tracking the initiation of microcracks and crack propagation by acoustic emission and dissipation of energy are presented. By measuring the coefficients of thermal expansion (CTE) of a basic lamina and the equations of classical lamination theory, CTE's of any laminate can be calculated. ESA

N86-30768# Politecnico di Milano (Italy). Dept. of Aerospace Engineering.
ANALYTICAL AND EXPERIMENTAL RESULTS OF ADVANCED COMPOSITE STIFFENED PANELS UNDER COMBINED LOADS
G. ROMEO *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 79-86 Feb. 1986 Sponsored by Italian Ministry of Education
Avail: NTIS HC A16/MF A01

A theoretical analysis to design advanced composite hat and blade-stiffened panels under uni and biaxial compression and/or shear is reported. The analysis is based on the buckling equation of the simply-supported orthotropic plate to predict the overall buckling of the panel and the local buckling of each cross-section element, and on the torsional instability theory for the blade-stiffened panels. A computer program to evaluate the minimum-mass optimization of the panels was designed. Tests on graphite/epoxy hat and blade-stiffened panels under uniaxial compression and unstiffened panels under shear were conducted. Adequate correlation between theoretical analysis and experimental results is obtained. ESA

N86-30770# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
ADEQUATE FIBER REINFORCED STRUCTURAL ELEMENTS IN LOAD INTRODUCTION AREA OF FIBER REINFORCED SHELLS
F. S. D. REKERS *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 95-99 Feb. 1986
Avail: NTIS HC A16/MF A01

Design of reinforcements around access holes and near cylinder ends in structural shells is discussed. Elements necessary for introduction of axial-load and bending moment in a cylinder are presented. Monolithical behavior; hoop stiffness; torsional stiffness; shear stiffness; and shear introduction were implemented in three different shell-configurations. ESA

N86-30771# Brussels Univ. (Belgium).
NEW PREDICTION METHODS FOR COMPOSITES HYGROTHERMAL BEHAVIOR
C. C. HIEL *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 101-107 Feb. 1986 Sponsored by NAS-NRC and NATO
Avail: NTIS HC A16/MF A01

A method to predict the thermal expansion and swelling of a composite material due to temperature and moisture variations which typically occur in a launch environment is presented. It is demonstrated that constitutive equations for moisture absorption and moisture-induced dimensional changes can be obtained with an internal variable method rooted in the theory of irreversible thermodynamics. Realism is injected into the model through the concept of free volume. ESA

N86-30777# California Univ., Berkeley. Dept. of Mechanical Engineering and Center for Advanced Materials.
DELAMINATION FRACTURE TOUGHNESS OF COMPOSITE SPACECRAFT STRUCTURES
C. K. H. DHARAN *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 159-167 Feb. 1986
(Contract DE-AC03-76SF-00098)
Avail: NTIS HC A16/MF A01

Opening mode (mode 1) delamination fracture behavior of graphite and aramid-epoxy composites was investigated. The effect of loading rate and reinforcement geometry (unidirectional vs woven) on fracture toughness was determined, and observation of the fracture surface was used to derive microfailure modes. A micromechanical delamination model to estimate the relative contributions of the matrix and the fiber-matrix interface to the overall delamination fracture toughness is proposed. Results show that the mode 1 delamination fracture toughness of graphite composites is small relative to glass composites. Woven graphite composites exhibit opening mode delamination crack energy release rates 2.5 times those of the unidirectionally reinforced material. The fracture surface of the graphite-epoxy laminates is characterized by clean exposed fiber surfaces indicating poor interfacial fracture toughness. ESA

N86-30778# Royal Inst. of Tech., Stockholm (Sweden). Dept. of Aeronautical Structures and Materials.
DAMAGE ZONE FRACTURE ANALYSIS OF FIBROUS COMPOSITES
K. HOLLMANN, P. CLARIN, C. G. ARONSSON, and J. BAECKLUND *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 169-174 Feb. 1986
Avail: NTIS HC A16/MF A01

Excellent results were achieved using the Damage Zone Model (DZM) to predict mode 1 fracture loads of notched composites. A computer program of high computational efficiency, called FRACOM, was developed. Computations are performed in a few minutes on a personal computer and result in an estimated load-displacement behavior and damage zone characteristics under quasi-static loading. ESA

N86-30779# Engineering System International, Rungis (France).
INDUSTRIAL CALCULATION OF DAMAGE TOLERANCE AND STRESS ALLOWABLES IN COMPONENTS MADE OF COMPOSITE MATERIALS USING THE PAM-FISS/BIPHASE MATERIAL MODEL
A. DEROUVRAY and E. HAUG *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 175-185 Feb. 1986 Sponsored by ESA/ESTEC
Avail: NTIS HC A16/MF A01

A finite element code to simulate the heterogeneous constitution of composite materials during the damage process was developed.

The code simulates the basic damage mechanisms; matrix micro and macrocracking, fiber ruptures, layer delamination. It is used to calculate initial, tangent, and residual rheological properties, as well as damage (or defect) initiation and stable/unstable growth, in the critical zones of arbitrary composite structures. It provides realistic equivalent homogeneous properties (moduli; stress/strain allowables) compatible with an efficient damage tolerant design. ESA

N86-30780# Paderborn Univ. (West Germany). Fachgebeit Technische Mechanik.
ON CORRELATION BETWEEN THERMAL STRESSES, ELASTIC STRAIN ENERGY AND DEBONDING IN THERMALLY LOADED FIBER-REINFORCED COMPOSITE MATERIALS
F. G. BUCHHOLZ *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 187-196 Feb. 1986
Avail: NTIS HC A16/MF A01

Correlations between thermal stresses, elastic strain energy, and the energy release rate during debonding of unidirectionally fiber reinforced composite materials are investigated numerically. It is shown that the strain energy caused by thermal loads in a single circular unit cell of such a material is directly correlated with the energy spent by the compound on debonding of fiber and matrix. For a corresponding hexagonal unit cell within a compound two additional influences are effective, resulting in an interferred correlation and distinctly lower energy release rates during the process of debonding. ESA

N86-30781# Strathclyde Univ., Glasgow (Scotland). Dept. of Mechanics of Materials.
ASSESSING THE EFFECTS OF DELAMINATIONS ON THE POSTBUCKLING STRENGTH OF CRFP PANELS
W. M. BANKS, J. RHODES, and G. B. CHAI *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 197-202 Feb. 1986 Sponsored by UK Ministry of Defense and ESA
Avail: NTIS HC A16/MF A01

The effect of deliberately inbuilt delaminations on the postbuckling strength of carbon fiber composite panels with a b/t ratio of 70 and 50 was tested. The panels are fabricated from 14 layers of unidirectional carbon fiber using an autoclave process. The delamination positions were chosen to coincide with the position of highest interlaminar shear stress, the position of highest direct strain, the central buckle peak, and the inflection points on the panel. The control panel for a b/t ratio of 68.57 failed prematurely due to unforeseen edge effects. However it is clear that the worst position for delamination is when it coincides with the highest interlaminar shear stress at the edge of the panel. There appears to be little effect with the delamination at the buckle peak. ESA

N86-30782# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
ON THE DEFECT SENSITIVITY OF SPACECRAFT TYPICAL THIN CFRP LAMINATES
J. BISCHOFF *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 203-209 Feb. 1986
Avail: NTIS HC A16/MF A01

The brittleness of high modulus CFRP laminates used in spacecraft was investigated. It is shown that small defects can cause a crucial reduction of loading capacity. The dependence of this reduction on fiber orientation and the laminate stacking sequence is discussed. Fiber-matrix-bonding is identified as an essential factor affecting the notch sensitivity. ESA

N86-30784# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
NONDESTRUCTIVE TESTING OF FIBER REINFORCED COMPOSITES USING X-RAY FINE STRUCTURE PROCEDURES
J. WALTER and HENSCHEL (Bundesanstalt fuer Materialpruefung, Berlin, West Germany) *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 217-229 Feb. 1986
Avail: NTIS HC A16/MF A01

Nondestructive inspection (NDI) of fiber reinforced composites is introduced. Nondestructive testing with the X-ray fine structure procedure is based on the fact that the paracrystalline microstructure of the fibers diffracts the X-rays at the lattice planes. The long chain molecules are arranged in a nearly crystalline (paracrystalline) configuration; the chains have a high degree of orientation parallel to the fiber axis, so that the X-ray pattern produced by a bundle of fibers irradiated in a directional normal to their long axis is typical for the specific type. This property can be used as NDI-criterion and thickness layer measurement method. ESA

N86-30785# Fulmer Research Inst. Ltd., Stoke Poges (England).
DEVELOPMENTS IN THE NONDESTRUCTIVE EVALUATION (NDE) OF COMPOSITE MATERIALS
R. L. CROCKER *In its* Proceedings of a Workshop on Composites Design for Space Applications (ESA-SP-243) p 231-235 Feb. 1986
Avail: NTIS HC A16/MF A01

The effects on composites inspection of digital techniques of computing and data storage, robotics, and image processing made possible by digitizing raw data are assessed. Ultrasonics, X-radiography, thermography, mechanical impedance, vibro-thermography, and laser holography are discussed. In many cases the actual defect detection capability is not changed by introducing these techniques, it is the integrity of the inspection or evaluation which is improved. ESA

N86-30794# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
STRENGTH OF CARBON FIBER COMPOSITE/TITANIUM BONDED JOINTS AS USED FOR SPAS-TYPE STRUCTURES
J. FRANZ and H. LAUBE *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 301-308 Feb. 1986
Avail: NTIS HC A16/MF A01

The analytical and experimental verification of bonded tubes used for SPAS strut assemblies is described. The strut elements consist of a carbon fiber tube and two titanium mounting elements, connected by tapered, double-shear bonded joints. The analysis of the geometric design minimized the shear stress peaks at the ends of the overlapping section under external and temperature loadings. The load capability is verified by a destructive qualification test program (static load and fatigue) and each individual strut is acceptance tested before integration into a satellite structure. Data can be used for load capability estimations for similar strut components, i.e., with increased or decreased tube diameter, or with modified overlapping length of the bonding section. ESA

N86-30799# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
A STEP TOWARDS AN ESA COMPOSITES DESIGN HANDBOOK FOR SPACE STRUCTURE APPLICATIONS
J. BOLZ *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 351-355 Feb. 1986
Avail: NTIS HC A16/MF A01

The European Space Agency initiated a Composites Design Handbook for Space Structure Applications, because the increasing application of composite materials in space structures requires harmonization. Establishment of a Handbook structure and the compilation of information on as many topics as possible is described. ESA

N86-30804# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
WINDING WITH THERMOPLASTIC POLYMERS
J. L. TISNE and J. BOUVARD 1986 8 p Presented at 3rd European Symposium on Spacecraft Materials in Space Environment, Noordwijk, Netherlands, 3 Oct. 1985 Previously announced as N86-22613
(SNIAS-861-430-106; ETN-86-97168) Avail: NTIS HC A02/MF A01

Filament winding of continuous fibers impregnated with thermoplastic resins for spacecraft structure manufacturing is described. The mandrel is at ambient temperature, or is maintained below the fusion temperature, which enables winding unstable trajectories by means of the under layer/strand sticking. Another method consists in having the material and the mandrel at the fusion temperature while winding. This process simplifies the machine but presents two drawbacks, with respect to the thermoset resins: it is impossible to wind other than stable trajectories, close to geodetic ones; and the curing on the thermoset epoxy (maximum 180 C) is replaced by a fusion in an oven (from 250 to 400 C). This poses a problem of resistance of the enclosed parts and tools. ESA

N86-31427*# Hawaii Univ., Honolulu. Dept. of Mechanical Engineering.
MATERIALS CONSIDERATIONS IN THE DESIGN OF A METAL-HYDRIDE HEAT PUMP FOR AN ADVANCED EXTRAVEHICULAR MOBILITY UNIT
B. E. LIEBERT *In* NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 62 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 20D

A metal-hydride heat pump (HHP) has been proposed to provide an advanced regenerable nonventing thermal sink for the liquid-cooled garment worn during an extravehicular activity (EVA). The conceptual design indicates that there is a potential for significant advantages over the one presently being used by shuttle crew personnel as well as those that have been proposed for future use with the space station. Compared to other heat pump designs, a HHP offers the potential for extended use with no electrical power requirements during the EVA. In addition, a reliable, compact design is possible due to the absence of moving parts other than high-reliability check valves. Because there are many subtleties in the properties of metal hydrides for heat pump applications, it is essential that a prototype hydride heat pump be constructed with the selected materials before a committment is made for the final design. Particular care must be given to the evaporator heat exchanger worn by the astronaut since the performance of hydride heat pumps is generally heat transfer limited. Author

N86-31634*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF AN OXYGEN PLASMA ON THE PHYSICAL AND CHEMICAL PROPERTIES OF SEVERAL FLUIDS FOR THE LIQUID DROPLET RADIATOR
D. A. GULINO and C. E. COLES 1986 12 p Proposed for presentation at the 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987; sponsored by the American Institute of Aeronautics and Astronautics
(NASA-TM-88839; E-3222; NAS 1.15:88839) Avail: NTIS HC A02/MF A01 CSCL 07D

The Liquid Droplet Radiator is one of several radiator systems currently under investigation by NASA Lewis Research Center. It involves the direct exposure of the radiator working fluid to the space environment. An area of concern is the potential harmful effects of the low-Earth-orbit atomic oxygen environment on the radiator working fluid. To address this issue, seven candidate fluids were exposed to an oxygen plasma environment in a laboratory plasma asher. The fluids studied included Dow Corning 705 Diffusion Pump Fluid, polymethylphenylsiloxane and polydimethlsiloxane, both of which are experimental fluids made by Dow Corning, Fomblin Z25, made by Montedison, and three fluids from the Krytox family of fluids, Krytox 143AB, 1502, and 16256, which are made by DuPont. The fluids were characterized by noting changes in visual appearance, physical state, mass, and infrared spectra. Of the fluids tested, the Fomblin and the three Krytoxes were the least affected by the oxygen plasma. The only effect noted was a change in mass, which was most likely due to an oxygen-catalyzed deploymerization of the fluid molecule. Author

N86-31639# Societe Nationale Industrielle Aerospatiale, Cannes (France).
USE OF MOS2 APPLIED BY PHYSICAL VAPOR DEPOSITION (PVD) ON SPACE MECHANISMS
J. F. PATIN, M. MAILLAT, and H. E. HINTERMANN 1986 6 p Presented at Second ESA European Symposium on Space Mechanisms and Tribology, Schloss Meersburg, West Germany, 9-11 Oct. 1985
(SNIAS-861-440-101; ETN-86-97610) Avail: NTIS HC A02/MF A01

The laboratory test results of sputter coatings of MoS2 are described. The lubricating film, produced using a physical vapor deposition technique was used in the Arabsat, SPOT and TDF satellites. The test program includes the study of the influence of many parameters, including speed, vacuum, temperature, load, and air humidity in the case of ground tests. The tests show that MoS2 is an excellent lubricant for space mechanisms. The only remaining problem is its high sensitivity to moisture when performing ground tests. ESA

N86-31641# Societe Nationale Industrielle Aerospatiale, Cannes (France).
NEW ALUMINUM ALLOYS FOR SATELLITE STRUCTURES
J. L. CECCONI and J. F. PATIN 1986 9 p
(SNIAS-861-440-111; ETN-86-97619) Avail: NTIS HC A02/MF A01

The utilization of aluminum-lithium alloys in spacecraft structures is discussed. The weight reduction attainable is 10% to 13% compared with other aluminum alloy options. The applications are examined and carbon fiber reinforced plastic alternatives are analyzed. It is shown that the optimum choice depends on the required shape and properties of the spacecraft constituents. ESA

N86-31668# Martin Marietta Aerospace, Denver, Colo.
DAMPING CHARACTERISTICS OF METAL MATRIX COMPOSITES Quarterly Letter Report
10 Apr. 1986 6 p
(Contract N00014-85-C-0857)
(AD-A167792; MCR-85-721) Avail: NTIS HC A02/MF A01 CSCL 11D

Damping test data of Gr/Al composites, from previous measurements at Martin Marietta Denver Aerospace, CO suggest that composites exhibit higher damping than aluminum and titanium base structural alloys. Enhanced material damping of metal matrix composite (MMC), as a structural material will significantly improve the stability control and reliability of space structures. The objectives of the present investigation are: (1) to identify the mechanism and the source of damping in MMC (P55 Gr/6061 Al); (2) to determine the role of microstructural parameters, e.g., fiber volume, fiber orientation and interfiber spacing, and (3) to define the role of fiber matrix interfaces. GRA

N86-32347# European Space Agency, Paris (France).
PREPARING FOR THE FUTURE: THE ESA TECHNOLOGICAL RESEARCH AND DEVELOPMENT PROGRAM 1986-1988 Executive Summary
N. LONGDON, ed. Dec. 1985 55 p Original document contains color illustrations
(ESA-SP-1079; ISSN-0250-1589; ETN-86-97566) Avail: NTIS HC A04/MF A01

European Space Agency work on Earth-space telematics; space communications; infrastructure; global Earth monitoring; deep space and observatory facilities; microgravity utilization; space platforms;

in-orbit operations; and maintenance of European competitiveness is outlined. ESA

N86-32537# Societe Nationale Industrielle Aerospatiale, Paris (France).
DEPLOYABLE ANTENNA REFLECTOR [REFLECTEUR D'ANTENNE DEPLOYABLE]
C. LABRUYERE 1986 6 p In FRENCH Presented at Journees Industrielles France-Canada, Ottawa, Ontario, 10-12 Sep. 1985
(SNIAS-861-422-117; ETN-86-97602) Avail: NTIS HC A02/MF A01

Carbon fiber structures for space operating deployable reflectors 4 to 40 m diameter for frequencies between 1 and 30 GHz are discussed. The reflector should be compatible with Ariane launcher transportation. The reflecting skin is gold plated molybdenum knitted wire. The computation software is operational, and deployment tests were carried out. ESA

N86-32584# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Product Assurance Div.
DATA FOR SELECTION OF SPACE MATERIALS
Nov. 1985 211 p
(ESA-PSS-01-701-ISSUE-1; ISSN-0379-4059; ETN-86-97796)
Avail: NTIS HC A10/MF A01

Data on adhesives, adhesive tapes, coatings and varnishes, glasses, lubricants, metals, paints, plastic films, potting compounds, reinforced and thermosetting resins, rubbers, and thermoplastics for space applications are presented. The materials were used by ESA. ESA

08

ASSEMBLY CONCEPTS

Includes automated manipulator techniques,-EVA, robot assembly, teleoperators, and equipment installation.

A86-32550
ROBOT SPACECRAFT SURVIVABILITY USING A DECISION TREE FOR DATA PROCESSING
A. M. CHANDE and R. W. NEWCOMB (Maryland, University, College Park) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 243-249. refs

This paper deals with the survivability of robot spacecraft in hostile and congested space environments. Outlined herein is a bottom-up tree that makes navigational and stability decisions and generates a sequence of control actuations for accurate trajectories for the robot spacecraft. The approach provides the spacecraft with a sense of survivability by virtue of its tactual abilities. A path towards creating an intelligent machine and associated processing regarding its surroundings is recommended. The decision-based strategy using knowledge based heuristics is introduced to achieve autonomous and/or human assisted trajectory determination and collision avoidance, making the robot spacecraft rugged for transits in complex environments. Author

A86-32929#
MOBILE GANTRY ROBOTS FOR LARGE STRUCTURES
D. FRAZIER (Martin Marietta Corp., Michoud Div., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 14 p.

A NASTRAN analysis was used to investigate the design and feasibility of transporting a large gantry robot for use in aerospace manufacturing. A model of a rectangular gantry of high tensile 4140 steel with a 400 pound carriage/manipulator mounted on top was constructed and tested by the sudden failure of one of the frictionless airskids on which the gantry was moving at constant speed. The locations and magnitudes of the extreme stresses are identified. C.D.

A86-34970
APPLICATION OF SOLIDS MODELING TECHNOLOGY TO SPACE STATION CONCEPTUAL DESIGN AND ON-ORBIT ASSEMBLY
R. R. YORK and S. B. RIDER (Martin Marietta Corp., Denver, CO) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 7-1 to 7-13.

The 'Geomod' solids-modelling technology has been applied to NASA Space Station proposal development efforts, aiding in the conceptual design of the common module and the Materials Technology Laboratory (MTL) as well as generating animation sequences depicting the complex technique of on-orbit assembly for the modules comprising the habitable elements of the Space Station. Attention is given to the experience gained from the conceptual design of the MTL, and the construction method animations. A videotape has been prepared from the animation sequences. O.C.

A86-34971
EVOLUTIONARY PATHS FOR ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN OPERATOR INTERACTIONS WITH SPACE STATION ROBOTS
R. A. HAMMOND, D. C. DORROUGH (Boeing Computer Services Co., Bellevue, WA), and D. P. MEYER (Boeing Aerospace Co., Seattle, WA) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 7-14 to 7-20.

Two paths have been proposed for the evolution of technologies supporting human interfacing with robots aboard the NASA Space Station: (1) the use of teleoperators (so that human operators are in the control loop as the robot operates) followed by the adoption of autonomous robotics, as the technology advances; and (2) the use of fully independent robots from the outset, but using simple task menus until more autonomous robotic technology is developed. Attention is given to the relative merits of each approach in the illustrative case of EVA robots for routine station keeping tasks. The route of essential robot autonomy is concluded to provide the better EVA system. O.C.

A86-37047*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE TELEROBOTICS - A FEW MORE HURDLES
J. E. PENNINGTON (NASA, Langley Research Center, Hampton, VA) IEEE, International Conference on Robotics and Automation, San Francisco, CA, Apr. 8-10, 1986, Paper. 5 p. refs

In the early 1990's, a telerobotic work system which can be used with the Mobile Remote Manipulator System (MRMS) on the Space Station is to become available. However, a number of difficulties have to be overcome before these plans can be realized. The word 'telerobotics' is used in connection with a system which can function as teleoperator, and which, in addition, has also autonomous functions. Thus, as a robot, the system would automatically perform selected operations using multisensory internal feedback for control. A role for telerobotics is defined, taking into account EVA servicing and repair work, remote satellite refueling, and operations during the Space Station development period. Attention is also given to the definition of a telerobotic system, the definition of the telerobotics technology set, and approaches related to the development of a telerobotic system. G.R.

A86-39503#
EXPERIMENTS IN OPTIMAL CONTROL OF A FLEXIBLE ARM WITH PASSIVE DAMPING
T. E. ALBERTS, G. G. HASTINGS, W. J. BOOK, and S. L. DICKERSON (Georgia Institute of Technology, Atlanta) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 423-435. Research supported by the Georgia Institute of Technology. refs (Contract NSF MEA-83-03539)

This paper presents a hybrid active and passive control scheme for controlling the motion of a lightweight flexible arm. A straightforward development of LaGrange's equations using a series expansion of assumed flexible modes provides a time domain model for controller design. The active controller design was approached as a steady state linear quadratic continuous regulator. A constrained viscoelastic layer treatment was employed to achieve passive damping. The passive damping treatment serves to enhance the system's stability while providing sound justification for the use of a highly truncated dynamic model and reduced order controller. Initial experimental results comparing controller performance with and without passive damping demonstrate the merit of the proposed combined active/passive approach. Author

A86-40508
RECENT ADVANCES IN TELEOPERATION - IMPLICATIONS FOR THE SPACE STATION
M. M. CLARKE (Rockwell International Corp., Downey, CA) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 4-1 to 4-10. refs

The paper describes recent advances in teleoperation in nonaerospace hostile environments and discusses their applicability to space-related teleoperation. For example, remotely maintainable manipulators can increase system availability while continuing to exclude the crew from the hostile environment. Force reflection and supervisory control can reduce the operator's fatigue and workload. The Universal Master Controller can increase the system control flexibility. Author

A86-42997
DECENTRALIZED CONTROL OF SEQUENTIALLY ASSEMBLED LARGE SPACE STRUCTURES
D. P. LOOZE, M. ATHANS, and J. S. ETERNO (Alphatech, Inc., Burlington, MA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1844-1851. refs

A novel design approach for the decentralized robust control systems of large space structures (LSS) is presented. A decentralized design approach whereby each subsystem controller is designed independently based on a subsystem design model, subsystem performance goals and subsystem errors is adopted so as to address the following issues: (1) the necessary architecture of the control system must be determined from the system structure, performance requirements and hardware implementations of the LSS; (2) the procedure must be able to handle a large number of variables that will be present in a realistic design problem; and (3) the procedure must incorporate LSS performance specifications and dynamic modeling errors. The advantages inherent in this approach are outlined and it is noted that the major technical difficulty which arises is that the coordination between the subsystem designs is accomplished through the subsystem performance and error specifications. In the present analysis, a number of techniques are developed which enable the decentralized design procedure to be applied to a specific simplified problem. The specific problem that is considered is the sequential assembly problem for two subassemblies. K.K.

A86-43341
CONTRACTS OF AND WITH PRIVATE ENTERPRISES CONCERNING THE DEVELOPMENT, THE CONSTRUCTION, AND THE ASSEMBLY OF SPACE VEHICLES [VERTRAEGE VON UND MIT PRIVATUNTERNEHMEN BETR. DIE ENTWICKLUNG, DEN BAU UND DIE MONTAGE VON RAUMFLUGKOERPERN]
E. WOLFF (Dornier System GmbH, Friedrichshafen, West Germany) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 89-99. In German. refs

This paper provides a representation of some special features which characterize development contracts that governmental agencies award to industrial enterprises. Particular attention is given to conditions in West Germany. However, approaches used in connection with contracts involving ESA and NASA are also considered. The origin of the development contract is discussed along with the objective of the development contract, questions regarding the legal qualification of the development contract, regulations regarding compensation in development contracts, assurances concerning the quality of the performed work, and the rights of the party awarding the contract with respect to information, participation, and control. G.R.

A86-43884
STATE OF THE ART IN INTELLIGENT/BRILLIANT ROBOTS
R. HONG (Grumman Aerospace Corp., Bethpage, NY) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 75-80. refs

The state of the art of intelligent/brilliant robots of various types which will be in operation in the next decades is addressed. These are robots which will possess human-like capabilities and beyond. As such, they will generally be implemented with artificial intelligence technology such as knowledge based/expert systems. Learning and self adaptive capabilities are also being applied to these future robots. Author

A86-43885
SHUTTLE REMOTE MANIPULATOR COLLISION-AVOIDANCE SYSTEM
J. G. MAUCERI (Sperry Corp., Great Neck, NY) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 89-94. refs

A brilliant collision avoidance system for use on the Shuttle Remote Manipulator is described. This paper will provide an overview of the complete system and address the details of the collision avoidance algorithm, and its implementation using Automated Reasoning. The system presented will possess the capabilities to manuever the RMS and payload around obstacles, learn by discovery, and reason about its environment as a human would. Author

A86-44550
ROBOTICS IN SPACE
P. NORRIS (Logica Space and Defence Systems, Ltd., Cobham, England) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 297-305.

The scope for the use of robotics in space in the coming two decades is reviewed. Lessons from the application of robotics on ground are used to suggest the most promising space-borne applications. The technical issues associated with robotics in space are examined. Author

A86-47053
CANADARM - A REVIEW OF ITS FLIGHTS
S. S. SACHDEV (Spar Aerospace, Ltd., Remote Manipulator Systems Div., Toronto, Canada) Journal of Vacuum Science and Technology A (ISSN 0734-2101), vol. 4, May-June 1986, pt. I, p. 268-272.

The Shuttle Remote Manipulator System (SRMS), or Canadarm, has been singularly successful in accomplishing both planned and unforeseen tasks in space. Following its first flight in November 1981, it has deployed payloads ranging in mass from 156 to 9765 kg. It has been flight tested for all its operating modes, its handling characteristics, and structural dynamics. It is now an operational subsystem of the Shuttle's Orbiter. The SRMS was instrumental in the retrieval and repair of the Solar Maximum Mission Satellite (SMM) in 1984, and featured prominently in the salvage of the Palapa and Westar Satellites later that year. It has been used as an extension of the human arm in unforeseen duties such as removing ice from the orbiter's waste management system and attempting to throw a switch on the malfunctioning Syncom Satellite. Most recently it has been part of an ingenious man/machine team in the in-orbit repair of the Syncom Satellite. A review of the highlights of the flight accomplishments of Canadarm is given. Author

A86-47404#
EXPERIMENTS ON THE END-POINT CONTROL OF A TWO-LINK ROBOT WITH ELASTIC DRIVES
M. G. HOLLARS and R. H. CANNON, JR. (Stanford University, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 19-27. refs
(Contract F49620-82-C-0092)
(AIAA PAPER 86-1977)

This paper discusses the use of end-point feedback to improve the position control performance of manipulators that have lumped sources of flexibility within the drive trains or joints. The links are assumed to be rigid. Four different control strategies are discussed and compared. Classical control using only position and rate sensors colocated at the motors gives limited performance and poor rejection of disturbances at the end-effector. Linear-Quadratic-Regulator full-state feedback with end-point position and rate sensing dramatically improves performance and disturbance rejection, but only for a certain class of trajectories in which linearized models are effective. Robust controllers designed for larger regions of motion improve the average performance of the manipulator but at the cost of specific performance. None of the above three constant-gain controllers performs well for a large class of desired trajectories in which the non-linear dynamics dominate. Non-linear computed-torque methods offer better performance for these cases. An experimental two-link manipulator has been constructed and experimental verification of these control strategies is in progress. Author

A86-47440*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN FOR A GOAL-ORIENTED TELEROBOTIC SYSTEM
R. W. WILL and N. O. SLIWA (NASA, Langley Research Center, Hampton, VA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 357-363. refs
(AIAA PAPER 86-2090)

Robotic systems will play an increasingly important role in space operations. This paper describes the objective and design of a proposed goal-oriented telerobotic system for space operations. This design effort encompasses the elements of the system executive and user interface, and the distribution and general structure of the knowledge bases, the displays, and the task sequencing. The objective of the design effort is to provide an evolutionary structure for a telerobotic system, i.e., one that can progress from strictly teleoperated through phases of serving as an assistant, a colleague, and an expert, to eventually serve as a truly autonomous unit, requiring only minimal supervision. A preliminary design for such a system involving 'mixed initiative', or the flexible shared control between the human operator and the software system, is complete and described in this paper. Author

A86-47467#
ON-ORBIT MANIPULATORS - SENSORY AND CONTROL APPROACHES
J. MCLAUGHLIN, B. STAUNTON, and L. WARD (Aerospace Corp., El Segundo, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 591-598. Research supported by the Aerospace Corp. refs
(AIAA PAPER 86-2185)

This paper presents an overview of ongoing research, describing work on some control issues relevant to space applications of robotics and teleoperation. Problems in manipulator path tracking, absolute position control, and link flexibility are addressed. A hardware experiment demonstrates the application of modern control design to trajectory control of a manipulator with nonlinear dynamics. Work on camera modeling and the use of computer vision and estimation in closed-loop position control is detailed. A two link, flexible manipulator is modeled and a linearization approach to controlling end-effector oscillations is simulated. Author

A86-47468#
A LABORATORY ROBOT FOR SPACE APPLICATION RESEARCH
H. FLASHNER, G. SHIFLETT (Southern California, University, Los Angeles), Y. GUO, and V. SPECTOR IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 599-607.
(AIAA PAPER 86-2186)

This paper discusses the development of the USC manipulator system, designed specifically for test and verification of control algorithms for space based robot applications. The robot features a simple but well defined mechanical configuration with modular components. Various dynamic characteristics can be easily modified allowing evaluation of their influence on system performance. A hybrid approach using digital and analog controllers was taken for the electromechanical design. Author

A86-47469#
AN ADAPTIVE VISION-BASED MANIPULATOR CONTROL SCHEME
S. B. SKAAR, W. H. BROCKMAN (Iowa State University of Science and Technology, Ames), and R. HANSON IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 608-614. refs
(Contract NSF MEA-83-18867)
(AIAA PAPER 86-2187)

A control strategy for manipulation of objects in space or under water is discussed and early experimental results for this strategy are reported. The strategy involves determining the relationship between servoable manipulator joint coordinates and the camera-space location of 'manipulatable' cues. If, due to camera motion of motion of the objects, the cues that are placed on the object of interest are nonstationary in camera space, the strategy uses models to predict the camera-space trajectories. A camera-space trajectory plan for the cues is then developed which is compatible with the limitations of the physical system and that results in the desired camera-space cue configurations. C.D.

A86-47923#
MODELING AND SIMULATION OF SPACECRAFT SOLAR ARRAY DEPLOYMENT
B. WIE, N. FURUMOTO, A. K. BANERJEE, and P. M. BARBA (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 237-242. refs
(AIAA PAPER 86-2122)

This paper presents the dynamic and digital simulation of the deployment of rigid solar panels on Intelsat-V and INSAT spacecraft. Each spacecraft is characterized by very distinct mechanisms for its solar array deployment. The arrays on Intelsat-V are in a topological tree configuration, while the INSAT arrays are in a closed-loop configuration because of the four-bar linkage deployment mechanism. It is shown that the kinematic control rod on the INSAT has a synchronizing function very similar to that of the closed cable loop on the Intelsat-V spacecraft. Practical aspects of the modeling and simulation of complex deployment mechanisms are emphasized. The use and limitations of the DISCOS multibody code for deployment dynamics simulations are discussed, and the need for developing specialized simulation tools emphasized. Author

A86-49552*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AUTOMATION AND ROBOTICS FOR SPACE STATION IN THE TWENTY-FIRST CENTURY
K. F. WILLSHIRE (NASA, Langley Research Center, Hampton, VA) and D. L. PIVIROTTO (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 7 p. refs
(AIAA PAPER 86-2300)

Space Station telerobotics will evolve beyond the initial capability into a smarter and more capable system as we enter the twenty-first century. Current technology programs including several proposed ground and flight experiments to enable development of this system are described. Advancements in the areas of machine vision, smart sensors, advanced control architecture, manipulator joint design, end effector design, and artificial intelligence will provide increasingly more autonomous telerobotic systems. Author

N86-24294# Cornell Univ., Ithaca, N.Y.
NONLINEAR DYNAMICS AND CHAOTIC MOTIONS IN FEEDBACK CONTROLLED ELASTIC SYSTEMS Annual Report, 1 Dec. 1983 - 30 Nov. 1984
P. J. HOLMES, F. C. MOON, and R. H. RAND Aug. 1985 29 p (Contract AF-AFOSR-0051-84)
(AD-A162385; AFOSR-85-1087TR) Avail: NTIS HC A03/MF A01 CSCL 12A

Local and global bifurcation studies of nonlinear systems subject to linear and nonlinear feedback forces have been completed which have application to robotic devices or controlled elastic structures. Related to these studies has been the application of mathematical knot theory to trace certain bifurcation sequences for two-dimensional maps. This work has led to the conclusion that many other routes to chaos in dynamical systems exist besides period doubling when the map is two-dimensional. The use of computer algebra (MACSYMA) has been developed as a tool to study nonlinear systems. In one application the investigators explored a new control scheme for flexible space structures based on controlling the stiffness matrix. MACSYMA was used along with normal form theory to predict the stability properties of a stiffness controlled systems. Other studies using MACSYMA related to problems in robotic dynamics were also completed or started. Finally, experimental work was completed involving the application of mathematics to chaotic motion of flexible structures. GRA

N86-27358# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
ANALYSIS OF IN-ORBIT PERFORMANCE OF MECHANISMS WITHIN LARGE STRUCTURES
H. BAIER *In* ESA Second European Space Mechanisms and Tribology Symposium p 29-34 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Simulating and predicting the behavior of spacecraft mechanisms especially within larger structures are discussed. Deployment kinematic analysis is outlined. Actuators and their transfer functions within an active isolation or damping system as well as investigations of the static behavior of a refocus mechanism and the dynamic behavior of a bearing and power transfer assembly are treated. For the latter case, the effects of nonlinearities and of static preloads are emphasized. Ways to verify mechanism behavior in flexible structures are summarized. ESA

N86-27363# Technische Univ., Munich (West Germany). Lehrstuhl B fuer Mechanik.
MODELING AND CONTROL OF A LIGHTWEIGHT ROBOT
B. GEBLER *In* ESA Second European Space Mechanisms and Tribology Symposium p 59-64 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

For a lightweight industrial robot the influence of elasticity of the structural parts is studied. The system is modeled as a hybrid multibody system. It is shown that using the static deflection bending lines as shape functions yields, with only a few degrees of freedom, very good results. For control of the system, consideration of nominal deflections is proposed. This concept takes into account the elastic properties of robot arms when computing feedforward control torques. ESA

N86-27369# Societe Nationale Industrielle Aerospatiale, Cannes (France).
SPEED REGULATORS FOR SPACE APPENDAGES DEPLOYMENT
J. M. LEBLANC *In* ESA Second European Space Mechanisms and Tribology Symposium p 105-111 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The requirements, design, test program, and performances of a centrifugal brake speed regulator for the deployment of spaceborne appendages are described. The regulator is qualified for the SPOT solar array, the TVSAT/TDF reflectors, and TELE-X reflectors. ESA

N86-27386# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
EXPERIMENT MANIPULATORS FOR AUTOMATIC SAMPLE HANDLING
N. CABLE *In* ESA Second European Space Mechanisms and Tribology Symposium p 221-226 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The application of robotics to small scale manipulator systems for materials handling in microgravity was studied, using the single core payload of EURECA. A skeleton and an advanced concept were studied. Modularity; size and mass; joint design; sensors; reliability, safety and redundancy; orbit and ground operation; computer aided design; end effectors; grapple fixtures; storage and process interfaces; processors; software; and the use of commercially available manipulators were investigated. ESA

N86-27388# Sener, S.A., Madrid (Spain).
A SENER LATCH DESIGN FOR DOCKING MECHANISMS
F. ABARRATEGUI, M. FUENTES, J. RIVACOBA, and J. A. ROS *In* ESA Second European Space Mechanisms and Tribology Symposium p 233-238 Dec. 1985
(Contract ESA-5195/82-NL-BI)
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Latch mechanisms were designed for the docking of two spacecrafts at relatively short distances and with small relative velocity between them. The mechanism mounted on one of the spacecrafts has to receive the passive element of the other, guide it, dissipate as much as possible the small relative kinetic energy, stop it, bring it to the final rest position, and rigidize the interface between both spacecraft. The mechanism elements necessary to carry out this task and the operation of the latch in the process of docking and undocking are explained. A model of the latch was built and tested in a bidimensional air bearing set-up. ESA

N86-27390# European Space Tribology Lab., Risley (England).
SOME RECENT EXPERIENCES OF MECHANISM PERFORMANCE AND COMPONENT ASSESSMENT IN THERMAL VACUUM TESTS AT ESTL
J. A. DUVALL and K. PARKER *In* ESA Second European Space Mechanisms and Tribology Symposium p 251-260 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The spacecraft mechanism test facilities at the European Space Tribology Laboratory (ESTL) are described. Test results are reviewed on three mechanisms where, in a variety of thermal conditions, the measurement of the reaction torque which would be experienced by the spacecraft was important. Valuable performance data is obtained when it is possible to dismantle mechanisms and examine the condition of all components after the tests. This was particularly important for two ESA mechanisms subjected to seven-year real life tests, one having lead-lubricated bearings and the other oil-lubricated bearings. The ESTL experience in component examination and failure analysis, with advice on how to improve mechanism reliability, is reviewed. ESA

N86-30234*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SIMPLE NONLINEAR JOINT MODEL
W. B. FICHTER Aug. 1986 7 p
(NASA-TM-87749; L-16169; NAS 1.15:87749) Avail: NTIS HC A02/MF A01 CSCL 20K

Hertzian contact theory is applied to a butt joint with specially mismatched bearing surfaces to devise a simple mathematical model of nonlinear axial force-displacement behavior in jointed members. Normalized tangent stiffness-force plots, for several values of a joint imperfection parameter, are presented for the sample case of solid structural members of circular section. The results illustrate the potential problem of high joint compliance at low axial-force levels, as well as the generally desirable stiffening and linearizing effects of preload. A nonlinear oscillator problem based on the static model is also formulated and solved to illustrate the effect of amplitude on natural frequency. As expected, natural frequency is low when amplitude is small. The results call attention to the important roles that tight tolerances and preload are expected to play in the design and fabrication of deployable and erectable truss-type space structures. Author

N86-33016*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
CONTROL OF A FREE-FLYING ROBOT MANIPULATOR SYSTEM Semiannual Report, Feb. - Jul. 1985
H. ALEXANDER and R. H. CANNON, JR. Jul. 1985 8 p
(Contract NCC2-333)
(NASA-CR-179717; NAS 1.26:179717; SAR-1) Avail: NTIS HC A02/MF A01 CSCL 05H

The goal of the research is to develop and test control strategies for a self-contained, free flying space robot. Such a robot would perform operations in space similar to those currently handled by astronauts during extravehicular activity (EVA). The focus of the work is to develop and carry out a program of research with a series of physical Satellite Robot Simulator Vehicles (SRSV's), two-dimensionally freely mobile laboratory models of autonomous free-flying space robots such as might perform extravehicular functions associated with operation of a space station or repair of orbiting satellites. The development of the SRSV and of some of the controller subsystems are discribed. The two-link arm was fitted to the SRSV base, and researchers explored the open-loop characteristics of the arm and thruster actuators. Work began on building the software foundation necessary for use of the on-board computer, as well as hardware and software for a local vision system for target identification and tracking. Author

N86-33024# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
CONTROL LOOPS WITH HUMAN OPERATORS IN SPACE OPERATIONS. PART 2: ROBOTICS OPERATIONS AND MANUAL CONTROL EXPERIMENT Final Report
C. M. VANSWIETEN and S. KAMPEN Paris ESA 5 Sep. 1985 140 p Prepared in cooperation with Royal Netherlands Aircraft Factories Fokker, Amsterdam
(Contract ESA-5594/83)
(NLR-TR-84116-L-PT-2; FOK-TR-R-84-CHO-131-PT-2; ESA-CR(P)-2190-PT-2; ETN-86-97788-PT-2) Avail: NTIS HC A07/MF A01

Servicing of satellites and assembly of space structures via robotic operations controlled from the ground by human operators are discussed. Five operational modes for the combined space and ground segment are defined: high level manipulation; manual augmented; preprogrammed; single joint (emergency mode); and direct drive (emergency mode). The main difficulty in the manual modes is the presence of time delay in the control loop and the way the operator can cope with it. Human operator performance was assessed for the direct drive mode, in which the system provides the least support. A simple model for this mode shows essentially nonlinear actuator behavior, which makes results from the literature not applicable. Therefore experiments were done. The experiments show that the operator can control the system, but a lot of overshooting responses are observed. Possibly, these overshoots can be eliminated by different instructions to the operator, who was instructed in the experiments to be as fast as possible. ESA

09

PROPULSION

Includes propulsion concepts and designs utilizing solar sailing, solar electric, ion, and low thrust chemical concepts.

A86-33203
FLEXIBILITY CONTROL OF SOLAR BATTERY ARRAYS OF SPACECRAFTS
T. FUKUDA, H. HOSOGAI, Y. KURIBAYASHI (Tokyo, Science University, Japan), and N. YAJIMA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Sakura, Japan) IN: A bridge between control science and technology. Volume 5 . Oxford and New York, Pergamon Press, 1985, p. 2933-2938. refs

The paper examines the problem of how to estimate and control the vibrational modes of flexible booms of the arrays in a reliable way even in large angle attitude maneuvers. A proposed mode estimation method, which makes use of differential outputs of instrument solar cells, gives a good estimation of the vibrational modes. Even static output maximization control in a desired direction cannot work stably without flexibility control, based on the mode estimation. The boom is controlled and implemented as a distributed parameter system by microprocessors. The dynamic control based on the feedback control theory can give good results

to suppress the vibration of the arrays even in large angle attitude maneuvers. The control system has fault tolerant properties, such as dual microprocessor controlled systems with independent fault self-diagnostic software, and can degrade itself as faults go into the worse. Author

A86-34174* Virginia Polytechnic Inst. and State Univ., Blacksburg.
MINIMUM-FUEL CONTROL OF HIGH-ORDER SYSTEMS
J. SHENHAR and L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 48, March 1986, p. 469-491. refs
(Contract NAG1-225)

The minimum-fuel control problem is of special interest in various space systems. To date, solutions of minimum-fuel control problems have been carried out for relatively low-order systems. Space structures, however, are generally characterized by a large number of degrees of freedom, so that minimum-fuel control of such systems requires a new approach. In the independent modal-space control (IMSC) method, the control laws are designed in the modal space for each mode independently. The minimum-fuel problem reduces to that of a set of independent second-order systems, so that minimum-fuel control is possible. This paper shows how the IMSC method can be used to control a space structure with a minimum amount of fuel. A numerical example is presented. Author

A86-34972
PROPULSION SYSTEM CONCEPT ASSESSMENT AND TECHNOLOGY REQUIREMENTS FOR SPACE STATION
W. F. RECTOR, III and M. W. HENLEY (General Dynamics Corp., Convair Div., San Diego, CA) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 7-21 to 7-30.

A development status assessment is presented for the alternative Space Station propulsion systems under consideration, identifying potential advantages and disadvantages of each. An outline is given of an advanced development program for the promising initial operational capability alternative of gaseous hydrogen and oxygen propellants; the advanced development work for such a system could support an early decision for the Space Station design. Maintainability, commonality and growth potential are among the major propulsion system evaluation criteria. O.C.

A86-34990#
POWER AND THERMAL MANAGEMENT CONCEPTS FOR FREE-FLYING PLATFORMS IN THE SPACE STATION ERA
H. O. CURTIS, P. R. PIERCE, K. R. JOHNSON, and D. R. CHALMERS (RCA, Astro Electronics Div., Princeton, NJ) Canaveral Council of Technical Societies, Space Congress, 22nd, Cocoa Beach, FL, Apr. 23-26, 1985, Paper. 11 p. refs

The use of space platforms for special scientific and commercial payloads will enhance the system capability of the Space Station program and spur the exploitation of low earth orbits. These platforms will be serviceable to promote low-cost extension of platform life, as well as to provide long term payload maintenance, repair and change-out. The power and thermal subsystems of these platforms threfore will be designed to satisfy a broad and evolving range of payload resource requirements, while providing maintainability and sericeability consistent with long life. Early designs highlight the need for, and impact of, modular configurations employing advanced technologies. Author

A86-34994#
DYNAMIC POWER - A KEY TO THE PROMISE OF SPACE
C. N. HALL and J. P. MULLIN (Sundstrand Corp., Sundstrand Advanced Technology Group, Rockford, IL) Canaveral Council of Technical Societies, Space Congress, 22nd, Cocoa Beach, FL, Apr. 23-26, 1985, Paper. 22 p. refs

The evolution of Rankine cycle power conversion equipment is traced, beginning with early designs of solar dynamic power conversion applications based on a mature terrestrial data base. This development then moves through applications which use various energy sources including radioisotopes and particular types of stored chemical energy. Current equipment designs viable for use on Space Station and possible SDI applications are described and compared with possible alternative solutions. Methods for accommodating growth to much larger power levels using solar power and chemical energy sources as well as nuclear heat sources are also discussed. K.K.

A86-36668
CONVERSION OF SOLAR ENERGY [PREOBRAZOVANIE SOLNECHNOI ENERGII]
N. N. SEMENOV, ED. and A. E. SHILOV, ED. Moscow, Izdatel'stvo Nauka, 1985, 184 p. In Russian. For individual items see A86-36669 to A86-36673.

The papers presented in this volume provide an overview of current theoretical and experimental research related to the conversion and practical utilization of solar energy. Topics discussed include semiconductor photovoltaic cells, orbital solar power stations, chemical and biological methods of solar energy conversion, and solar energy applications. Papers are included on new theoretical models of solar cells and prospects for increasing their efficiency, metrology and optical studies of solar cells, and some problems related to the thermally induced deformations of large space structures. V.L.

A86-38623
NUCLEAR POWER FOR EARTH ORBIT AND BEYOND
B. NOLLEY Space World (ISSN 0038-6332), vol. W-5-269, May 1986, p. 18-20.

The development of space-based thermoelectric nuclear power generators for such future applications as the propulsion of an Orbital Transfer Vehicle or planetary exploration is discussed. Nuclear fission reactors have a higher power/mass ratio than radioisotope or chemical generators, less atmospheric drag, and will not be dependent on attitude control. The NASA in-core thermionics SP-100 nuclear fission reactor prototype is expected in the mid-1990s. A low mass 6.4 percent efficient multimegawatt capability reactor is described with a fast spectrum reactor in the cone's apex, separate from the two silicon-germanium element thermoelectric conversion system. Liquid lithium transports heat from the 1970-C reactor to heat exchanges that convey it to the heat pipe array, and heat rejection occurs at the deployable radiator panels. R.R.

A86-42608#
NUCLEAR POWERED ION ENGINE ORBIT TRANSFER VEHICLE DESIGN AND OPERATIONAL EFFECTIVENESS
S. P. MAHONEY (USAF, Satellite Test Center, Sunnyvale Air Force Station, CA) and M. M. MEKARU (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. refs
(AIAA PAPER 86-1391)

The feasibility and the cost effectiveness for using nuclear powered electric propulsion orbit transfer vehicles (EOTV) to move Block 3 Navstar Global Positioning System (GPS) satellites from low earth orbit (LEO) to a 10,900 nm orbit are determined. The electric propulsion systems considered are present and 1990's technology ion engines using mercury, xenon or argon for a propellant. A systems cost model which combines payload, power source, trajectory, and earth-to-LEO launch parameters with algorithms characterizing the electric propulsion system is used. The least costly systems which had an outbound triptime equal to or less than 90 days are determined. These systems are then compared with the PAM D-II, Centaur-G, and IUS in terms of total deployment costs for 28 GPS satellites launched at a rate of four per year for seven years. The study finds that a reusable EOTV with 37 Xenon ion engines powered by a nuclear reactor can perform the mission for less cost than the chemical systems. Author

A86-42615*# Rockwell International Corp., Canoga Park, Calif.
SPACE STATION PROPULSION TEST BED - A COMPLETE SYSTEM
G. L. BRILEY, A. M. NORMAN (Rockwell International Corp., Rocketdyne Div., Canogo Park, CA), L. JONES, and H. CAMPBELL (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1402)

A test bed was fabricated under NASA/MSFC (Marshall Space Flight Center) Contract NAS8-36418 to demonstrate hydrogen/oxygen propulsion technology readiness for the Initial Operating Conditions Space Station application and for use as a means to test evolving technology for the growth station. This paper describes the test bed and its function. Author

A86-42616*# Technion, Inc., Irvine, Calif.
A 10,000 HOUR LIFE MULTIPROPELLANT ENGINE FOR SPACE STATION APPLICATIONS
T. K. PUGMIRE, G. L. CANN (Technion, Inc., Irvine, CA), B. HECKERT (Rockwell International Corp., Canoga Park, CA), and J. S. SOVEY (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. Research supported by Johnson Matthey, Inc. and Engelhard Corp. refs
(AIAA PAPER 86-1403)

A review of the design background and operating objectives of a multipropellant resistojet is presented. An engine has been designed to operate with carbon dioxide, methane, water, hydrazine decomposition products and hydrogen. Design performance has been constrained to ensure a 10,000-hour life. The engine, constructed primarily of grain stabilized platinum, is to operate at temperatures up to 1400 C. General performance guidelines, design and fabrication methods are reported. Author

A86-42617*# Textron Bell Aerospace Co., Buffalo, N. Y.
A LONG-LIFE 50 LBF H2/O2 THRUSTER FOR SPACE STATION AUXILIARY PROPULSION
J. M. SENNEFF (Bell Aerospace Textron, Buffalo, NY) and G. P. RICHTER (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(AIAA PAPER 86-1404)

In preparation for the development of a manned Space Station, the National Aeronautics and Space Administration (NASA) is conducting a program to develop technology related to on-board Auxiliary Propulsion Systems. To develop the required thruster technology to support the Space Station project, the NASA Lewis Research Center has sponsored a development program based on a unique 'reverse flow' concept where the fuel is injected 'backwards' in the chamber to cool the spherical combustor wall. This combustor was based on previous developments at the 50-lbf, 1000-lbf, and 1500-lbf thrust levels. This paper describes the design and test program carried out to demonstrate a new 50-lbf thruster, the design which was based on this previous technology. Included are the test results for the initial mixture ratio 4 thruster which can operate with uncooled Cres (stainless steel) combustor walls. In addition, the effort to operate a thruster redesigned for operation at a mixture ratio of eight for potential integration with the life support system is described. Author

A86-42618#
LIFE CYCLE COST METHODOLOGY FOR SPACE STATION PROPULSION SYSTEM
C. J. MEISL (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. refs
(AIAA PAPER 86-1405)

A Life Cycle Cost (LCC) model was developed for the space station propulsion system to support the requirement and configuration trade studies. The model was conceived to be flexible in its structure in order to handle the large variations in propulsion concepts with regard to propellants, hardware, space station characteristics and operational support schemes. The model categorizes LCC into four cost segments, i.e., development, production, transportation, and operational support. The methodology is described with regard to model structure, assumptions and ground rules, types of Cost Estimating Relationships (CERs) used, validation, and input/output features. Typical cost analysis results are presented to illustrate the application of the methodology. These cover several propulsion concepts using hydrazine and oxygen/hydrogen as propellants. A comparison is made with previously published cost data by JPL, and the cost differences are explained. The methodology includes cost risk, and a description of the risk approach and the different elements of risk are provided. Author

A86-42623*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TWO-STAGE EARTH-TO-ORBIT VEHICLES WITH SERIES AND PARALLEL BURN
J. A. MARTIN (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.
(AIAA PAPER 86-1413)

Recent studies have indicated that a fully reusable earth-to-orbit vehicle system will be needed near the beginning of the next century. One likely concept is a two-stage, vertical takeoff system with liquid rocket propulsion. Such vehicles have been examined with series burn and parallel burn of the engines of each stage. The results indicate that the preferred concept will have parallel burn with crossfeed, the booster will have hydrocarbon engines, the Orbiter will have both hydrocarbon and hydrogen engines, and the staging velocity will be low enough to allow the booster to glide back to the launch site. Author

A86-42713#
A PROVEN 25-LBF H2/O2 THRUSTER FOR SPACE STATION AUXILIARY PROPULSION
P. J. ROBINSON and S. E. ROSENTHAL (Aerojet TechSystems Co., Sacramento, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1560)

A 25-lbF GO2/GH2 thruster for the Space Station propulsion system has been designed, fabricated and successfully tested under a NASA Lewis Research Center-sponsored technology program. Analytical models have been developed to predict thermal and performance characteristics of the thruster. Although originally designed to operate over a mixture ratio range of 3.0 to 5.0, the thruster has been tested over the range from 2.2 to 8.1. The total accumulated firing time and impulse to date are 22,198 seconds (6.166 hours) and 538,457 lbF-sec, respectively, with the longest steady state burn being 2200 seconds at 7.5 mixture ratio.
Author

A86-42714*# Rockwell International Corp., Canoga Park, Calif.
OXYGEN/HYDROGEN SPACE STATION PROPULSION SYSTEM CONCEPT DEFINITION FOR IOC
J. M. SHOJI, C. J. MEISL, J. F. GLASS, W.-H. TU, S. J. EBERT, S. A. EVANS (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA), L. W. JONES, and H. CAMPBELL (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 23 p. refs
(AIAA PAPER 86-1561)

The potential for the reduction in propulsion system life cycle costs through the use of on-board water electrolysis to generate oxygen and hydrogen propellants, as well as the potential advantages of improved system safety and contamination impact, led to a study to evaluate candidate oxygen-/hydrogen-based propulsion systems. In this study a representative set of propulsion system requirements were compiled and candidate oxygen/hydrogen-based propulsion systems synthesized. These candidate concepts were screened and a systems evaluation was performed on the remaining eight candidate concepts. Detailed

system schematics were prepared. Operational design conditions were determined and system weight, volume, energy requirements, and costs were calculated. Evaluation results indicated that the oxygen/hydrogen propulsion systems can provide simple, low cost, and viable systems for the IOC Space Station. Based on these data, a relative concept evaluation was conducted using as selection criteria reliability, safety, cost, technical risk, contamination, operational utility, growth potential, and integration potential. Top ranked candidate systems were recommended to NASA/MSFC for consideration for the IOC Space Station.
Author

A86-42715#
MONOPROPELLANT HYDRAZINE SYSTEMS FOR SPACE STATION APPLICATIONS
H. S. HILLBRATH and J. C. CONCEPCION (Boeing Aerospace Co., Huntsville, AL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1562)

Hydrazine systems using catalytic monopropellant decomposition thrusters are attractive candidates for space station propulsion applications. They offer low technical risk, low initial cost and favorable contamination characteristics. The modular configuration seems to offer some advantages in maintainability and safety. Hydrazine toxicity hazards in the space station environment are a principal source of concern. Other systems under evaluation are also attractive, especialy several types of GO2/GH2 systems which have higher initial cost, but lower operating cost due to higher specific impulse. Evaluation of the testing done in this program and others indicates that thruster life time may not be as significant a cost driver as was initialy thought. Testing has confirmed that mixing waste gasses with the hydrazine thruster exhaust products results in substantially more total impulse that would be obtained from the two fluids separately. A self-testing fluid connector has been designed, constructed and tested. Design concepts for a minimum spill disconnect are being developed. Both concepts are applicable to hydrazine and other hazardous fluid system.
Author

A86-42716*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED PROPULSION FOR POLAR-ORBITING AND COORBITING FREE FLYERS
B. A. PALASZEWSKI (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. NASA-supported research. refs
(AIAA PAPER 86-1564)

Advanced propulsion systems for polar-orbiting and coorbiting free flyers were investigated. Resistojet, arcjet, ion, magnetoplasmadynamic and chemical-bipropellant nitrogen tetroxide/monomethyl hydrazine (NTO/MMH) propulsion systems were compared to the baseline free-flyer hydrazine (N2H4)-propulsion-system performance. Advanced resistojet, arcjet, ion, and NTO/MMH propulsion systems enable significant propellant-mass savings over the baseline N2H4-propulsion system. Using free-flyer mission requirements from the Langley Research Center Mission-Data Base, detailed propulsion requirements for over thirty free-flyer missions were analyzed. The Polar-Platform trip-time constraints may preclude using a low-thrust electric-propulsion system. Electric propulsion will, however, allow a significant coorbiter propellant-mass reduction. Frequent servicing and nodal-regression effects on the coorbiting free-flyer's orbit increase the required mission velocity change and propellant mass. For many coorbiter missions high-specific-impulse resistojet-, arcjet- and ion-propulsion systems allow substantial life-cycle propellant-mass savings.
Author

A86-42799*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA ELECTROTHERMAL AUXILIARY PROPULSION TECHNOLOGY
J. R. STONE (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 19 p. Previously announced in STAR as N86-24749. refs
(AIAA PAPER 86-1703)

Electrothermal auxiliary propulsion systems provide high performance options which can have major mission benefits. There are several electrothermal concepts which offer a range of characteristics and benefits. Resistojets are the highest thrust to power option and are currently operational at mission average values of specific impulse, I sub sp approximately 295 sec. Long life, multipropellant resistojets are being developed for the Space Station, and resistojet technology advancements are being pursued to improve the I sub sp by more than 20 percent for resistojets used in satellite applications. Direct current arcjets have the potential of I sub sp over 400 sec with storable propellants and should provide over 1000 sec with hydrogen. Advanced concepts are being investigated to provide high power density options and possible growth to primary propulsion applications. Broad based experimental and analytical research and technology programs of NASA are summarized and recent significant advances are reviewed.
Author

A86-43206
PARAMETRIC DESIGN AND PRELIMINARY MISSION ANALYSIS OF A PROPOSED HYBRID OTV WITH TOS/AMS (TM) SOLID-FUEL BOOSTERS, AND RING-CUSP ION RETURN ENGINES
L. W. MADDOX (USAF, Space Command, Colorado Springs, CO) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 75-92. refs
(AAS PAPER 85-304)

This study addresses the problem of slow transfer time inherent in low-thrust electric propulsion. The study consists of two parts. The first part defines the partially reuseable Hybrid Orbit Transfer Vehicle (HOTV) parametrics. The TOS/AMS system boosts the vehicle from Shuttle or Space Station orbit to operational orbits and the ring-cusp ion system brings payload(s) and vehicle back to low orbit. The second part of the study uses first order dynamics to evaluate the HOTV operating envelope and examines possible missions in earth orbit. Missions found to be feasible with the HOTV include: observe and return, replace, service, retrieve, and satellite rescue. This HOTV is primarily limited to inspection missions at GEO, but still has clear advantages over refuelable liquid-rocket and aerobraked OTVs.
Author

A86-44447#
RIT-10 LOW-THRUST CONTROL OF EURECA'S ORBITAL DECAY
R. MUGELLESI and J. C. VAN DER HA (ESA, Orbit Attitude Div., Darmstadt, West Germany) (IAF, Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985) ESA Journal (ISSN 0379-2285), vol. 10, no. 1, 1986, p. 59-70. refs

The possibility of using the RIT-10 low-thrust experiment to control Eureca's orbital decay during its free-flight phase is investigated. The optimal thruster switch-on and switch-off points are determined taking into account the thrusting direction relative to that of the Carrier's velocity. An analytical model of the changes in the orbital elements under such a switching strategy has been constructed. Two control strategies are proposed, the first aimed at keeping the semi-major axis constant, and the second at maintaining a prescribed decay level. The benefit of a controlled Eureca orbital decay is substantial in that the target-node error for retrieval is thereby reduced. Consequently, fuel savings can be made during the rendezvous with the retrieving Shuttle.
Author

A86-47460#
PRELIMINARY EVALUATION OF A REACTION CONTROL SYSTEM FOR A SPACE STATION
H. H. WOO, E. T. FALANGAS, and J. A. FINLEY (Rockwell International Corp., Downey, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 538-546. Research sponsored by Rockwell International Corp.
(AIAA PAPER 86-2152)

The Space Station reaction control system (RCS) functions include disturbance damping, reboost maneuvers, and rotation maneuvers. This paper presents the design concepts and methodology used to define the RCS and simulation results used to evaluate the design performance. The objective is to present a preliminary RCS concept that meets the given functional, operational, and performance goals and requirements. RCS design concepts incorporate notch-bending filters, multiple-level switching functions, and integral trims. To evaluate these concepts in terms of performance, simulation data including attitude, rate, torque, and deflection time histories are presented for cases involving reboost, attitude maneuvers, disturbance conditions, and maneuvers during assembly. The RCS accommodation of a blowdown propulsion system with distributed propellant tanks is also evaluated. Author

A86-47910#
REDUCED RISK TWO STAGE TRANSFERS TO GEOSYNCHRONOUS ORBIT BY USE OF AN OPTIMIZED INTERMEDIATE TRANSFER ORBIT
R. E. COFFEY (Ball Corp., Ball Aerospace Systems Div., Boulder, CO) and J. R. STUART (Orbital Sciences Corp., Vienna, VA) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 98-105. refs
(AIAA PAPER 86-2063)

Recent experience has shown the inherent risk associated in delivering a payload onto geosynchronous transfer orbit using currently available upperstage technology. As a consequence of this risk, an increased burden is placed on the customer to insure against high launch and replacement costs brought about with payload losses. Mission reliability is shown to be greatly increased and delivery risk lowered by use of an optimum intermediate transfer orbit allowing for checkout and return of a faulty payload, or continued ascent to geostationary orbit. The optimum (minimum energy) intermediate transfer orbit is developed for a nonplanar and coplanar transfer from a standard shuttle parking orbit circular altitude to geostationary altitude. The optimum intermediate orbit for the nonplanar transfer is shown to differ from the classic modified Hohmann transfer, to be invariant to payload mass delivered onto the geostationary orbit, and to dictate design parameters for new efficient transfer stage architectures. Author

A86-47969#
A DESIGN FOR FLUID MANAGEMENT IN SPACE
N. E. SEARBY AIAA Student Journal (ISSN 0001-1460), vol. 23, Winter 1986, p. 6-9, 15. refs

Liquid-gas degassification, solid-liquid-gas separation, and algae growth, separation and harvesting are the problems primarily addressed by the present low energy system for fluids management in space conditions. The system incorporates a centrifugal approach in which a divergent, truncated conical spinning separation chamber is coupled with density-dependent valving. The degassification of fluids and separation of multiphased media are achieved while the pumping pressures required for the movement of the separated media to storage areas are generated. O.C.

A86-48206#
OPERATION AND CONTROL OF SPACE-BASED SOLAR ENERGY POWER PLANTS WITH CCGT USING HELIUM AS A WORKING MEDIUM
A. SUTSCH (Institute for Computer-Assisted Research in Astronomy, Alterswil, Switzerland) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs
(ASME PAPER 86-GT-152)

The generation of both electricity and process heat for industrial manufacturing systems aboard a large space station is presently addressed by a solar energy powerplant employing a closed cycle gas turbine that uses helium as its working fluid. Attention is given to the optical properties of the parabolic solar concentrator disk used, as well as to the thermodynamics of the helium cycle and the design features of the turbomachinery used. It is noted that the turbomechanical component of the helium-based system is substantially more compact than that of a steam-based system of comparable output. A 50-MW electrical output and a 60 MW thermal output are projected. O.C.

A86-49553*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLUID MANAGEMENT AND ITS ROLE IN THE FUTURE OF SPACE STATION
J. SALZMAN, R. VERNON, M. HILL, and T. PETERSON (NASA, Lewis Research Center, Cleveland, OH) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 14 p. refs
(AIAA PAPER 86-2301)

Technological challenges and suggested plans for meeting them pertaining to fluid management in the Space Station are discussed. A short overview is given of the major Space Station systems and operations which employ or rely on fluid management, followed by a description of the general system issues and challenges encountered in managing fluids in space. Examples of some current and near term activities directed toward providing the understanding and technologies necessary to overcome relevant problems are presented. Finally, suggested plans for similar but longer range research and development activities are offered. These plans emphasize the requirements and benefits of expanded in-space experiments, with the ultimate aim of using the Space Station as a facility for fluid management research and technology development efforts. C.D.

N86-24025# AEG-Telefunken, Wedel (West Germany).
ALTERNATIVE MODULE CONFIGURATIONS FOR ADVANCED SOLAR ARRAYS ON LOW ORBIT AND EXTENDED LIFETIME MISSIONS (AMOC 1) Final Report
D. GRINGEL, J. KOCH, and W. SCHMITZ Paris ESA Jan. 1985 166 p
(Contract ESTEC-5508/83-NL-PB(SC))
(ESA-CR(P)-2129) Avail: NTIS HC A08/MF A01

The applicability and power improvement of the p-grid solar cell for low Earth orbit missions were assessed. The power improvement predicted analytically is confirmed by electrical performance measurements. Two measurement methods were used: separate illimination of front and rearside; and simultaneous illumination of front and rearside. Bifacial cells were bonded onto window type and continuous type substrates for electrical performance determination. Test samples composed of different substrate materials covered with solar cells or glass dummies were tested with respect to the expected thermal environment and mechanical behavior. Three favorable substrate designs were selected for a thermal cycling test: glass or carbon fiber reinforced Kapton modules, and treated glass cloth module. Electric performance increase is 10% to 15% after 15,000 cycles at plus or minus 100 C, compared to standard BSFR cells.
Author (ESA)

N86-26358*# Evansville Univ., Ind. Dept. of Physics.
THEORETICAL STUDY ON THE EFFECT OF THE DESIGN OF SMALL (MILLI-NEWTON) THRUSTER JETS ON MOLECULAR CONTAMINATION FOR THE SPACE STATION Final Report, 15 Nov. 1985 - 30 Jun. 1986
B. R. RILEY 1986 44 p refs
(Contract NAG3-674)
(NASA-CR-177263; NAS 1.26:177263) Avail: NTIS HC A03/MF A01 CSCL 22B

The self-induced molecular contamination around the space station could have adverse effects on space station components (for example solar panels) as well as scientific experiments that might be done on or near the space station. Aerospace engineers need to design a space station (SS) propulsion system that keeps the SS in a stable orbit and at the same time does not allow the propellant gases to interfere with the experiments of the user. One scenario that might accomplish the above requirements is to use an electrothermal propulsion system, resistojet, that will thrust continuously in the hundreds of milli-Newton range which will provide a constant altitude for the SS with a low g environment. As a first attempt to understand the contamination from such a propulsion system, a point source model was developed. The numerical results of the point source model are given. Number column densities for CO2 are presented as a function of direction of observation (line of sight), temperature of the exit gas, and mean exit velocity. All the results are for a constant exhaust rate of 5,000 kg/year. In addition, a mathematical model to study the effect of nozzle design on the induced molecular environment around the space station produced by simple gas propellants is described. The mathematical model would allow one to follow the expansion of the gas from the throat of a nozzle to the nozzle exit plane and then into the space external to the nozzle. M.G.

N86-26369*# Rockwell International Corp., Canoga Park, Calif. Rocketdyne Div.
ORBIT TRANSFER ROCKET ENGINE TECHNOLOGY PROGRAM: ADVANCED ENGINE STUDY, TASK D.1/D.3 Interim Report
A. MARTINEZ, C. ERICKSON, and B. HINES Jan. 1986 237 p
(Contract NAS3-23773)
(NASA-CR-175084; NAS 1.26:175084; RI/RD86-116) Avail: NTIS HC A11/MF A01 CSCL 21H

Concepts for space maintainability of OTV engines were examined. An engine design was developed which was driven by space maintenance requirements and by a failure mode and effects (FME) analysis. Modularity within the engine was shown to offer cost benefits and improved space maintenance capabilities. Space operable disconnects were conceptualized for both engine change-out and for module replacement. Through FME mitigation the modules were conceptualized to contain the least reliable and most often replaced engine components. A preliminary space maintenance plan was developed around a controls and condition monitoring system using advanced sensors, controls, and condition monitoring concepts. A complete engine layout was prepared satisfying current vehicle requirements and utilizing projected component advanced technologies. A technology plan for developing the required technology was assembled. Author

N86-28991# Stuttgart Univ. (West Germany).
PLASMA THRUSTER DEVELOPMENT: MAGNETOPLASMA-DYNAMIC PROPULSION, STATUS AND BASIC PROBLEMS Interim Report, Oct. 1984 - Sep. 1985
R. D. BUEHLER Feb. 1986 108 p Prepared in cooperation with AF Rocket Propulsion Lab., Edwards AFB, Calif.
(Contract AF-AFOSR-0394-84)
(AD-A165945; IRA-85-P6; AFRPL-TR-86-013) Avail: NTIS HC A06/MF A01 CSCL 21C

This report provides an overview of the present state and the problem areas of magnetoplasmadynamic (MPD) space propulsion devices and systems potentially suitable for orbit raising and maneuvering of large space structures, i.e., thrust and power levels of presently most promising steady (or quasisteady pulsed) thruster types, self field, axial applied field arcjets and Hall ion thrusters are reviewed in terms of performance trends, present understanding, uncertainties and ground testing problems, with the conclusion that there is as yet no reliable basis for choosing one type for final development. Typical efficiency vs. specific impulse curves for all MPD thrusters show the dominant role of the propellant on the thrust to input power ratio (as for ion engines), and the necessity of achieving relatively high specific impulse values for each propellant for acceptable efficiencies. The specific impulse (or onset) limit of self-field thrusters using a variety of propellants is discussed, together with predicted trends from several theoretical models. Considering system complexity and development cost as well as performance, the advantages and disadvantages if pulsed (quasisteady) vs. continuous thruster operation and the propellant selection criteria are reviewed. Electrode erosion, especially on cathodes, losses and limits imposed by radiation cooling are emphasized as critical problem areas for larger MPD thrusters. GRA

N86-31647*# Rockwell International Corp., Canoga Park, Calif. Propulsion Programs.
SPACE STATION PROPULSION TECHNOLOGY Annual Progress Report, 24 May 1985 - 23 May 1986
G. L. BRILEY 1986 92 p
(Contract NAS8-36418)
(NASA-CR-178897; NAS 1.26:178897; RI/RD86-226; REPT-0737P-105-; APR-1) Avail: NTIS HC A05/MF A01 CSCL 21H

The progress on the Space Station Propulsion Technology Program is described. The objectives are to provide a demonstration of hydrogen/oxygen propulsion technology readiness for the Initial Operating Capability (IOC) space station application, specifically gaseous hydrogen/oxygen and warm hydrogen thruster concepts, and to establish a means for evolving from the IOC space station propulsion to that required to support and interface with advanced station functions. The evaluation of concepts was completed. The accumulator module of the test bed was completed and, with the microprocessor controller, delivered to NASA-MSFC. An oxygen/hydrogen thruster was modified for use with the test bed and successfully tested at mixture ratios from 4:1 to 8:1. B.G.

N86-32522*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROVEN, LONG-LIFE HYDROGEN/OXYGEN THRUST CHAMBERS FOR SPACE STATION PROPULSION
G. P. RICHTER and H. G. PRICE 1986 20 p Presented at the 1986 JANNAF Propulsion Meeting, New Orleans, La., 26-28 Aug. 1986; sponsored by JANNAF Interagency Propulsion Committee
(NASA-TM-88822; E-3171; NAS 1.15:88822) Avail: NTIS HC A02/MF A01 CSCL 21H

The development of the manned space station has necessitated the development of technology related to an onboard auxiliary propulsion system (APS) required to provide for various space station attitude control, orbit positioning, and docking maneuvers. A key component of this onboard APS is the thrust chamber design. To develop the required thrust chamber technology to support the Space Station Program, the NASA Lewis Research Center has sponsored development programs under contracts with Aerojet TechSystems Company and with Bell Aerospace Textron Division of Textron, Inc. During the NASA Lewis sponsored program with Aerojet TechSystems, a 25 lb sub f hydrogen/oxygen thruster has been developed and proven as a viable candidate to meet the needs of the Space Station Program. Likewise, during the development program with Bell Aerospace, a 50 lb sub f hydrogen/oxygen Thrust Chamber has been developed and has demonstrated reliable, long-life expectancy at anticipated space station operating conditions. Both these thrust chambers were based on design criteria developed in previous thruster programs and successfully verified in experimental test programs. Extensive thermal analyses and models were used to design the thrusters to achieve total impulse goals of 2 x 10 to the 6th power lb sub f-sec. Test data for each thruster will be compared to the analytical

predictions for the performance and heat transfer characteristics. Also, the results of thrust chamber life verification tests will be presented. Author

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GENERAL

Includes either state-of-the-art or advanced technology which may apply to Large Space Systems and does not fit within the previous categories. Publications of conferences, seminars, and workshops are covered in this area.

A86-30113* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
LUNAR BASES AND SPACE ACTIVITIES OF THE 21ST CENTURY
W. W. MENDELL, ED. (NASA, Johnson Space Center, Houston, TX) Houston, TX, Lunar and Planetary Institute, 1985, 875 p. For individual items see A86-30114 to A86-30174, A86-30176 to A86-30180.

The present conference gives attention to such major aspects of lunar colonization as lunar base concepts, lunar transportation, lunar science research activities, moon-based astronomical researches, lunar architectural construction, lunar materials and processes, lunar oxygen production, life support and health maintenance in lunar bases, societal aspects of lunar colonization, and the prospects for Mars colonization. Specific discussions are presented concerning the role of nuclear energy in lunar development, achromatic trajectories and the industrial scale transport of lunar resources, advanced geologic exploration from a lunar base, geophysical investigations of the moon, moon-based astronomical interferometry, the irradiation of the moon by particles, cement-based composites for lunar base construction, electrostatic concentration of lunar soil minerals, microwave processing of lunar materials, a parametric analysis of lunar oxygen production, hydrogen from lunar regolith fines, metabolic support for a lunar base, past and future Soviet lunar exploration, and the use of the moons of Mars as sources of water for lunar bases. O.C.

A86-31259
SECTAM XII - PROCEEDINGS OF THE TWELFTH SOUTHEASTERN CONFERENCE ON THEORETICAL AND APPLIED MECHANICS, PINE MOUNTAIN, GA, MAY 10, 11, 1984. VOLUME 2
Auburn, AL, Auburn University, 1984, 586 p. No individual items are abstracted in this volume.

Subjects in the area of fluid mechanics are discussed, taking into account heat-up flows of a contained fluid, an analytical solution for natural convection in a vertical oriented porous annulus, the Weissenberg effect generated by a torsionally oscillating rod in a layered medium, a system analysis for a model of bluff body base flow, steady solutions of the shallow water equations, and the subsonic near-wake of an axisymmetric body with a slanted base. Computational methods are considered along with structural vibrations, structural stability, experimental methods, coastal hydrodynamics, dynamical systems, large space structural systems, the hydraulics of sediment transport, localization of deformation, wave propagation, vibrations of plates and shells, composite materials, and design studies. Attention is given to damage tolerance studies in operational aircraft, design verification testing of advanced prototype structures, continuous filament wound grid stiffened composite structures for aircraft fuselages, and Navier-Stokes solutions for two-dimensional subsonic base flow. G.R.

A86-31260
CONFERENCE ON DECISION AND CONTROL, 23RD, LAS VEGAS, NV, DECEMBER 12-14, 1984, PROCEEDINGS. VOLUME 1
Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1984, 688 p. No individual items are abstracted in this volume.

Various papers on decision and control in engineering are presented. The general topics addressed include: estimation and filtering, stochastic adaptive control nonlinear systems, model order reduction, new approaches to stability problems of electric power systems, reliable/robust control and some applications to large-space structures, production planning and control of manufacturing systems, control systems governed by nonlinear partial differential equations, generalized state-space systems, and frequency-domain design of multivariable control systems. Also discussed are: identification, implementation issues and applications of adaptive control, analysis and synthesis of nonlinear input-output responses, signal processing, voltage VAR modeling and control for power systems, optimal control and filtering algorithms, analysis of queueing networks and related systems, control of distributed parameter systems, computer-aided technology, control of linear systems, and failure detection and fault-tolerant systems. C.D.

A86-31776
GUIDANCE AND CONTROL 1985; PROCEEDINGS OF THE EIGHTH ANNUAL ROCKY MOUNTAIN CONFERENCE, KEYSTONE, CO, FEBRUARY 2-6, 1985
R. D. CULP, ED. (Colorado, University, Boulder), E. J. BAUMAN, ED. (Colorado, University, Colorado Springs), and C. A. CULLIAN, ED. (Ball Corp., Ball Aerospace Systems Div., Boulder, CO) Conference sponsored by AAS. San Diego, CA, Univelt, Inc. , 1985, 616 p. For individual items see A86-31777 to A86-31808.

Consideration is given to the history of classical control theory and the current guidance and control theory taught at universities. Papers are presented on payload isolation, precision pointing spacecraft experiments, the evaluation of spacecraft disturbances, the performance of a laser communications pointing and tracking system, and the hardware and working models of control-related components and subsystems. Topics discussed include spacecraft attitude control, new guidance, navigation and control components, space repair mission activities, and on-orbit control systems. I.F.

A86-32095*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MAINTAINABILITY PLANNING FOR THE SPACE STATION
G. R. EGAN (NASA, Johnson Space Center, Houston, TX) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 5 p.
(AIAA PAPER 86-9754)

The planned NASA Space Station, which is expected to have many years of on-orbit operation, for the first time confronts spacecraft designers with major questions of maintainability in design. A Maintainability Guidelines Document has been distributed to all Space Station Definition and Preliminary Design personnel of the Space Station Program Office. Trade studies are being performed to determine the most economical balance between initial (reliability) cost and life cycle cost (crew time and replacement hardware) costs. O.C.

A86-32117*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SUBSYSTEM TESTING OF GALILEO'S ATTITUDE AND ARTICULATION CONTROL FAULT PROTECTION
L. L. ANDERSON and D. M. COHEN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 6 p. NASA-supported research. refs
(AIAA PAPER 86-9783)

This paper discusses the fault protection tesing of the Attitude and Articulation Control Subsystem (AACS) of the Galileo

spacecraft. The need for an autonomous fault protection system on an interplanetary spacecraft is discussed. Galileo requirements for the detection and response of specific hardware failures is discussed along with the fault protection software design and implementation. The test beds and test methods used for fault protection testing are described. The paper concludes with a presentation of the results of this testing with an emphasis on requirement and design changes that were made as a result of these tests. Author

A86-32407
OPTICAL FABRICATION AND TESTING WORKSHOP: LARGE TELESCOPE OPTICS, ALBUQUERQUE, NM, MARCH 4-8, 1985, PROCEEDINGS
R. S. MCDOWELL, ED. (Los Alamos National Laboratory, NM) Workshop sponsored by OSA and SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 542), 1985, 83 p. For individual items see A86-32408 to A86-32417.
(SPIE-542)

The present conference considers outstanding problems in the fabrication of large telescopic optics, new design opportunities in high precision space telescope mirrors due to materials-selection tradeoffs, mirror substrate scalability criteria in light of fabrication limitations, improved coatings for large astronomical telescope mirrors, the development status of a large 'optical generator' grinder apparatus for telescopic mirrors, and the development status of glass mirrors for space telescopes. Also discussed are trends in optical telescope technology, design aspects of the University of Texas 7.6-m telescope, the fabrication of the Keck 10-m telescope's primary mirror, the 'bend-and-polish' mirror fabrication technique, and the optics of the 15-m National New Technology Telescope. O.C.

A86-32526
EASCON '85: NATIONAL SPACE STRATEGY - A PROGRESS REPORT; PROCEEDINGS OF THE EIGHTEENTH ANNUAL ELECTRONICS AND AEROSPACE SYSTEMS CONFERENCE, WASHINGTON, DC, OCTOBER 28-30, 1985
Conference sponsored by IEEE, Boeing Electronics, Inc., General Electric Co., et al. New York, Institute of Electrical and Electronics Engineers, Inc., 1985, 387 p. For individual items see A86-32527 to A86-32566.

Aspects of the Space Transportation System technology are discussed, taking into account a review of high payoff technologies, structures and materials technology issues for reusable launch vehicles, advanced rocket propulsion system technology required to reduce LEO payload costs, advanced airbreathing propulsion as an enabling key to affordable aerospace transportation, a hypersonic aerothermodynamics status report, avionics and automation, and strategies to minimize Delta V costs of extraterrestrial resources. Other subjects studied are related to the Space Transportation System policy/programs, civil space program technology, civil space program policy, the common space support program, and the control of unclassified technology with military and space applications. Topics concerning the commercial space program are considered, giving attention to processing and services, policy, and boosters and transfer vehicles. G.R.

A86-32552
SDI ORBITAL SYSTEM TIMING CONSTRAINTS
J. R. LOCKER (SofTech, Inc., Fairborn, OH) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 265-272. refs

Configuration issues for an SDI system are driven by two types of constraints: those dictated by limits of technology and those dictated by the physics of the problem. The tradeoffs chosen for a given configuration will in turn drive the CCC problem. This CCC paper identifies the major configuration issues for a system of orbital platforms and characterizes the tradeoffs in terms of technology and physics. The underlying physical variables which impact all tradeoffs for the system are identified as platform height of orbit and distance between platforms. It is shown that all system level configuration variables may be considered in terms of these two variables, and implicitly, the speed of light lag in interplatform communication. Building upon this basis, some candidate system configurations are presented which make certain technological assumptions. It is shown, based upon system level functional analysis of these technological assumptions, that the major technological configuration drivers are primarily weapon system pointing and tracking capability. Author

A86-32904
MAN'S PERMANENT PRESENCE IN SPACE; PROCEEDINGS OF THE THIRD ANNUAL AEROSPACE TECHNOLOGY SYMPOSIUM, UNIVERSITY OF NEW ORLEANS, LA, NOVEMBER 7, 8, 1985
Symposium sponsored by AIAA. New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 813 p. For individual items see A86-32905 to A86-32934.

Papers are presented on the need, and capabilities of the Space Station, managing fluids in space, propellant supply for space operations, and the effect of the space environment on spacecraft materials. Topics discussed include docking concepts, a launch system, the designs and planning of a lunar base/lunar city, space applications of composite structures, and the fabrication of composite tooling. Consideration is given to FAA air traffic control program management technology applications, the application of thermal analysis to polyurethane prepolymeric materials, surface sensitive techniques for the analysis of ET polymers, nondestructive measurements of residual stress, integrated logistics support, and mobile gantry robots for large structures. I.F.

A86-32909#
SEALING FOR LONG-TERM SPACE APPLICATION
P. B. ALLEN and H. W. BECKER (Martin Marietta Corp., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 35 p. Research supported by the Martin Marietta Independent Research and Development Program. refs

The performances of various seals in a space environment are examined. The design and applicability of elastomeric O-rings molded from nitrile, neoprene, fluorocarbon, and silicones are analyzed. The use of nylon and teflon plastic seals for split piston rings and backup and wear rings is discussed. The advantages and disadvantages of metallic seals and gaskets are studied. Test procedures for evaluating static seals and sealants for temperature and pressure in a simulated space environment are desribed. I.F.

A86-32912#
ALTERNATIVE DOCKING CONCEPTS FOR APPLICATION TO THE SPACE STATION
D. S. MONITOR (Martin Marietta Corp., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 25 p. refs

Studies of the International Space Station utilization have identified concerns relating to the rendezvous and docking operations of all space vehicles with the Space Station. Some of these concerns include contamination of the immediate environment and exposed surfaces by the Reaction Control System (RCS) exhaust products, Space Station attitude disturbances produced by the RCS exhaust plume pressure fields, and the Space Station structural response resulting from the residual velocity differences between two docking bodies. The use of remote docking facilities supported by either extensible arms or a tether combined with approaches along the orbital radius vector may attentuate these effects and satisfy the concerns. Author

A86-33226
INTERNATIONAL SYMPOSIUM ON AEROELASTICITY AND STRUCTURAL DYNAMICS, 2ND, RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE, AACHEN, WEST GERMANY, APRIL 1-3, 1985, COLLECTED PAPERS
Symposium organized by DGLR; Supported by BMFT. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, 713 p. For individual items see A86-33227 to A86-33261, A86-33263 to A86-33291.
(DGLR BERICHT 85-02)

The present conference considers topics in the unsteady aerodynamics and aeroelastic characteristics of aircraft structures, active structural control technologies, structural modeling and optimization methods, structural system identification, and the structural dynamics design verification of space structures. Specific attention is given to the transonic equivalent strip method for aeroelastic applications, transonic unsteady methods for the calculation of flutter airloads, experimental and analytical buffeting investigations of a delta wing, the application of unsteady wing collocation methods to subsonic flow cascades, a static aeroelastic analysis employing aircraft vibration modes, and a general theory for the finite state modeling of aeroelastic systems for active control applications. Also discussed are the use of control law synthesis for gust load alleviation using linear quadratic Gaussian theory, the stiffness control of large space structures, the variation of isotropic behavior in structural optimization, the dynamic analysis of structures with flexible rotors, modal parameter estimation from driven-base tests, rapid vibration mode analysis of aircraft with external stores, and low frequency design verification of large spacecraft structures. O.C.

A86-34110
U.S. OPPORTUNITIES IN SPACE CONFERENCE; PROCEEDINGS OF THE SECOND ANNUAL SPACE BUSINESS CONFERENCE, WASHINGTON, DC, OCTOBER 30-NOVEMBER 1, 1985
Conference organized by Space Consultants International, Ltd. London, Space Consultants International, Ltd., 1985, 264 p. For individual items see A86-34111 to A86-34123.

Papers are presented on the capabilities and commercial opportunities for materials processings in space, remote sensing systems, and the application of space technologies to terrestrial projects. Topics discussed include the privatization of Expendable Launch Vehicles and the legal issues related to commercialization. Consideration is given to the Leasecraft system, 'Canadarm', and the Space Station. I.F.

A86-34123#
THE CANADARM - ON EARTH AS IT IS IN SPACE
C. G. TRUMP (Spar Aerospace, Ltd., Toronto, Canada) IN: U.S. Opportunities in Space Conference; Proceedings of the Second Annual Space Business Conference, Washington, DC, October 30-November 1, 1985 . London, Space Consultants International, Ltd., 1985, 9 p.

Canada's contributions to space technology are reviewed. The development of the Shuttle Remote Manipulator System, which is used on manned US spacecraft and in the device used to fuel the Candu nuclear reactors, is described. Canada's satellite communication system is examined. Future Canadian space projects such as a mobile satellite system and space-based radar surveillance system are discussed. I.F.

A86-34574
MOTION TRAJECTORIES OF PARTICLES INSIDE AND OUTSIDE AN ORBITING SPACE SHUTTLE
H. F. BAUER (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Jan.-Feb. 1986, p. 22-33.

In connection with the conduction of space missions, certain tasks, as, for instance, the assembly of space stations in orbit, will involve the placement of objects outside the space vehicle. Such objects may be subjected to certain forces, including aerodynamic drag and lift from a residual atmosphere. The present study has the objective to assess the effect of some of the forces on the relative motion of a system outside a space laboratory in cases in which constant and time-variant forces have to be considered. Attention is given to the disturbed motion of a mass point due to an oscillatory force, disturbed motion due to a pulse, the dynamics of a mechanical mass point system, and numerical evaluations and conclusions. G.R.

A86-34951
SPACE AND SOCIETY - PROGRESS AND PROMISE; PROCEEDINGS OF THE TWENTY-SECOND SPACE CONGRESS, COCOA BEACH, FL, APRIL 23-26, 1985
Congress sponsored by the Canaveral Council of Technical Societies. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, 411 p. For individual items see A86-34952 to A86-34989.

A collection of papers is presented which examines improvements in space systems operations, new initiatives in the procurement process for space technology, and technological developments supporting future initiatives. The reporting of mission results and plans for the future by worldwide sources is addressed. The general topics covered include: operational efficiency in STS, remote operation in space and robotics, contracting and management, space systems technology, Spacelab mission results, advanced missions and transportation, Space Station technology, international programs, productivity in space activities, Getaway spacial program, and energy. C.D.

A86-34992*# National Aeronautics and Space Administration, Washington, D.C.
ENABLING TECHNOLOGIES FOR TRANSITION TO UTILIZATION OF SPACE-BASED RESOURCES AND OPERATIONS
S. R. SADIN (NASA, Office of Aeronautics and Space Technology, Washington, DC) and J. D. LITTY (General Research Corp., Space Systems Div., McLean, VA) Canaveral Council of Technical Societies, Space Congress, 22nd, Cocoa Beach, FL, Apr. 23-26, 1985, Paper. 10 p.

This article explores a potential scenario for the further development of space infrastructure resources and operations management. It is a scenario that transitions from the current ground-based system to an architecture that is predominantly space-based by exploiting key mission systems in an operational support role. If this view is accurate, an examination of the range of potential infrastructure elements and how they might interact in a maximally productive space-based operations complex is needed, innovative technologies beyond the current Shuttle and Space Station legacy need to be identified, and research programs pursued. Development of technologies within the areas of telerobotics, machine autonomy, human autonomy, in-space manufacturing and construction, propulsion and energy is discussed. Author

A86-35426
AEROSPACE BEHAVIORAL ENGINEERING TECHNOLOGY CONFERENCE, 4TH, LONG BEACH, CA, OCTOBER 14-17, 1985, PROCEEDINGS
Conference sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc., 1985, 444 p. For individual items see A86-35427 to A86-35458.
(SAE P-168)

Papers are presented on assessing human fitness and performance; the use of simulation as a cockpit design tool; the man-machine interface; the Space Station; and human performance. Consideration is given to advanced transport aircraft technology; operator workload analysis; rotorcraft missions; the pilot in the operational loop; and flight crew training. Topics also discussed include cockpit communications; color displays; commercial air transport and general aviation operations; and space and military operations. I.F.

A86-37176
AEROSPACE SIMULATION II; PROCEEDINGS OF THE SECOND CONFERENCE, SAN DIEGO, CA, JANUARY 23-25, 1986
M. UNG, ED. (Southern California, University, Los Angeles, CA) San Diego, CA, Society for Computer Simulation (Simulation Series. Volume 16, No. 2, 1986), 1986, 304 p. For individual items see A86-37177 to A86-37195.

Papers are presented on techniques for optimizing computer performance in real-time flight simulation; the effects of simulator variation on the fidelity of a UH-60 Black Hawk simulation; a real-time simulation for helicopter rotor wind-tunnel operations; simulation support software in a real-time environment; simulation of auto-rendezvous and docking; a generic missile weapon system model for war-gaming; and the optimal missile nonlinear multiloop controller design principle. Topics discussed include the modeling of a tethered two-body system in space; the testing of a spacecraft attitude control system; Space Station dynamic modeling; interactive mission planning for a Space Shuttle flight experiment; hybrid simulation of ejection seat dynamics, adaptive autoregressive target modes' identification; and optimal control of air-launched homing missiles using realistic performance indices. Consideration is given to flow separation and dynamic stall research, transonic trailing edge flow, fluid dynamics, man/machine interface, computer generated image time delays, the simulation of a satellite attitude control system, and the application of flight simulators to the development of advanced fighter flight control. I.F.

A86-37852
INTERNATIONAL CONFERENCE ON SPACE, 25TH, ROME, ITALY, MARCH 26-28, 1985, PROCEEDINGS [CONVEGNO INTERNAZIONALE SULLO SPAZIO, 25TH, ROME, ITALY, MARCH 26-28, 1985, ATTI]
Conference sponsored by the Ministero per il Coordinamento delle Iniziative per la Ricerca Scientifica e Tecnologica, Ministero degli Affari Esteri, FAO, and ESA. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, 487 p. In Italian and English. For individual items see A86-37853 to A86-37881.

Various papers are presented on space station missions and programs, utilization, configuration, subsystems, services, as well as miscellaneous topics concerning space stations. Individual subjects addressed include: the U.S. Space Station program, European participation in international space stations, the views of the U.S. scientific community on the Space Station, prospects for the life sciences and microgravitational experiments in the Space Station, data and communications infrastructure for the Space Station, polar platforms, and the Ariane 5 space transportation system. Also discussed are: attitude stability of a class of tethered space stations, large space structural models combining finite elements and transfer matrix methods, inflatable technology in orbit demonstration, design of the ESA thematic mapper processing chains, and an energy balance study by satellite imagery. Several papers are also presented on the Italian Space Agency and on the Italian-Chinese SIRIO program. C.D.

A86-38051
INTERNATIONAL INSTRUMENTATION SYMPOSIUM, 31ST, SAN DIEGO, CA, MAY 6-9, 1985, PROCEEDINGS
Symposium sponsored by ISA. Research Triangle Park, NC, Instrumentation Society of America (Instrumentation in the Aerospace Industry. Volume 31; Advances in Test Measurement. Volume 22), 1985, 808 p. For individual items see A86-38052 to A86-38084.

Consideration is given to techniques for measuring pressure, temperature, and solid mechanics, blast and shock instrumentation, flow measurements, measurement errors, and uncertainty analyses. Topics discussed include the applications of mini/microcomputers, data acquisition, processing, and analysis techniques and systems, and real-time control and display systems. Papers are presented on weighing instruments for space, special test facilities and data reduction procedures, flow applications, and wind tunnel instrumentation and control. Emphasis is given to the study of electrooptic and fiber optic instrumentation, NDT and acoustic emissions, software development for instrumentation, and science policies and the role of the government concerning scientific developments. I.F.

A86-38540
STRUCTURAL DYNAMIC TESTING AND ANALYSIS; AEROSPACE TECHNOLOGY CONFERENCE AND EXPOSITION, LONG BEACH, CA, OCTOBER 14-17, 1985, TECHNICAL PAPERS
Conference and Exposition sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-635), 1986, 115 p. For individual items see A86-38541 to A86-38548.
(SAE SP-635)

Papers are presented on a normal mode identification test using multiple inputs; a global technique for estimation of modal parameters from measured data; and a comparison of experimental and analytical structural dynamics using a modal assurance criterion. Topics discussed include the design of an optimal seismic isolation system; modal randomness induced by boundary conditions; and eigenvector relations for natural vibrations of damped systems. Consideration is given to the constrained adjustment of analytical stiffness matrices; the multiple boundary condition test; smoothing errors in Fourier transform-based modal data analysis; and the synthesis of discrete passive vibration dampers. I.F.

A86-38551
SPACECRAFT DESIGN AND OPERATIONAL PROBLEMS: PROCEEDINGS OF THE AEROSPACE TECHNOLOGY CONFERENCE AND EXPOSITION, LONG BEACH, CA, OCTOBER 14-17, 1985
Conference and Exposition sponsored by SAE, Martin Marietta Corp., McDonnell Douglas Corp., et al. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-636), 1985, 58 p. For individual items see A86-38552 to A86-38556.
(SAE SP-636)

Papers are presented on space and launch vehicle designs and flight operations. Topics discussed include flight planning with the NASA Flight Design System and flight planning techniques for mixing deployable payloads on the Space Shuttle. Consideration is given to health and safety in the Shuttle environment and spacecraft software costs. I.F.

A86-38801
STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS CONFERENCE, 27TH, SAN ANTONIO, TX, MAY 19-21, 1986, TECHNICAL PAPERS. PARTS 1 & 2
Conference sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, 1986. Pt. 1, 788 p.; pt. 2, 706 p. For individual items see A86-38802 to A86-38950.

Among the topics discussed are finite nodal point methods, the Advanced Software Environment for Automated Design, verification methods for large beam-type space structures, a nonlinear optimization expert system, a transfinite element methodology for unified thermal/structural analysis, hysteresis and energy dissipation in metallic tubes, ingot metallurgy Al-Li alloys for aircraft, a cryogenic tank design for the Orbital Transfer Vehicle, a structural analysis of the controlled impact demonstration of a jet transport aircraft, and the mechanical property degradation of advanced composites in aircraft service. Also treated are the thermostructural behavior of composite sandwich structures, the synthesis of structures with multiple frequency constraints, the aeroelastic behavior of forward-swept graphite/epoxy wings with rigid body freedoms, the buckling of viscoelastic beam columns, and the effect of crack growth rate variations on life predictions. Finally, attention is given to cracking in military transport pressure bulkheads, a modular approach to three-dimensional structural shape optimization, the aeroelastic tailoring of composite wings with external stores, and the effect of load history on cumulative damage in a composite solid propellant. O.C.

A86-39476
DYNAMICS AND CONTROL OF LARGE STRUCTURES; PROCEEDINGS OF THE FIFTH SYMPOSIUM, BLACKSBURG, VA, JUNE 12-14, 1985
L. MEIROVITCH, ED. (Virginia Polytechnic Institute and State University, Blacksburg) Symposium sponsored by the Virginia Polytechnic Institute and State University and AIAA. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, 605 p. For individual items see A86-39477 to A86-39511.

Papers are presented on Space Station on-orbit parameter and disturbance identification, the identification of a damping matrix from model data, structural parameter identification using modal response data, a Neumann series approach to random vibrations, and the evaluation of performance characteristics for a space antenna system subjected to stochastic disturbances. Also considered are spacecraft uniform damping control, the control of traveling waves in flexible structures, the control of civil engineering structures, balanced augmented controller reduction, and closed-loop stability of large space structures with reduced-order controllers. Other topics include dynamics of gyroelastic vehicles, a matrix approach to dynamics formulation of complex space structures, linear regulator control of the hoop-column antenna, and a robust nonlinear attitude control law for space stations with flexible structural components. Papers are also presented on experiments in optimal control of a flexible arm with passive damping, the effects of sensor and actuator errors on static shape control for large space structures, maneuvering of flexible spacecraft with application to SCOLE, a slewing control experiment for flexible structures, and single step optimization strategies for constrained retargeting maneuvers. R.R.

A86-39477*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ON-ORBIT PARAMETER AND DISTURBANCE IDENTIFICATION FOR SPACE STATION
D. S. BAYARD, F. Y. HADAEGH, and C. C. IH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 1-18. refs

This paper describes recent efforts directed at the problem of on-orbit parameter and disturbance identification for the Space Station. Techniques are developed for identification of rigid body parameters, flexible body parameters, and quasi-static disturbances relevant to the Power Tower configuration currently under investigation by NASA. The paper concludes with a case study investigating the identification of modal frequencies in a 15 degree of freedom planar model of the Space Station under a variety of operational settings. Author

A86-39981
REAL FANTASY [REAL'NAIA FANTASTIKA]
S. P. UMANSKII Moscow, Izdatel'stvo Moskovskii Rabochii, 1985, 242 p. In Russian.

The need for the continual exploration of outer space is emphasized, and the ultimate benefits in store for mankind are presented in detail. The pioneers of rocket technology, the first flights into outer space, and developments in astronautics are discussed as well as the design of rockets, spacecraft, and orbital space stations. Lunar features are examined, and plans for lunar-based scientific investigation are described. Attention is given to results of investigations conducted on Mars and Venus, the design of Mars probes, and the instruments used to study Venus. Plans for flights to nearby stars are also described. K.K.

A86-40501
SPACE TECH; PROCEEDINGS OF THE CONFERENCE AND EXPOSITION, ANAHEIM, CA, SEPTEMBER 23-25, 1985
Conference and Exposition sponsored by ASM, ASME, IEEE, et al. Dearborn, MI, Society of Manufacturing Engineers, 1985, 413 p. For individual items see A86-40502 to A86-40529.

The conference presents papers on the geostationary platform as an application of the Space Station, and continuous fiber composite hoops as well as guidance, controls and sensors, artificial intelligence and robotics, material applications, simulation and software, space structures, habitation, manufacturing for and in space, propulsion and communications. Attention is focused on reentry guidance and control for an Aeroassist Flight Experiment, a two-dimensional near-infrared tracking system, robotic nondestructive inspection of aerospace structures, the cost of materials in space, an orbital maneuvering vehicle simulator and the effect of pressurization on natural frequencies and modes of vibration of orthotropic cylindrical shells. Also considered are concepts for a permanent human lunar colony, Mars survival kit engineering, automation requirements derived from space manufacturing concepts, optimizing cutting tool performance in high tensile strength materials, and communications and tracking as the keys to Space Station utilization. K.K.

A86-40509
ROBOTIC NONDESTRUCTIVE INSPECTION OF AEROSPACE STRUCTURES
G. L. WORKMAN and W. TEOH (Alabama, University, Huntsville) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 4-11 to 4-24.

Nondestructive inspection of critical components and systems used in aerospace structures requires that the inspection system provide a consistent scanning capability to determine structural integrity in a timely and cost-effective manner. The scanning system may be single-ended, as in pulse echo electronics or eddy currents, or double-ended as in through transmission ultrasonics or X-ray applications. Many of the scanning systems developed in the past for automated nondestructive inspection of large structures such as aircraft wings or fuselages usually are designed specifically for that application and can be very expensive. There is no built-in flexibility for scanning other types of structures; hence there is a need for general purpose scanning systems which use the industrial robot as a programmable scanning device. Author

A86-40576
SPACE SYSTEMS TECHNOLOGY CONFERENCE, SAN DIEGO, CA, JUNE 9-12, 1986, TECHNICAL PAPERS
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1986, 259 p. For individual items see A86-40577 to A86-40608.

Papers are presented on liquid droplet radiator thermal characteristics, battery designs, mobile satellite communications, space-based air traffic surveillance, the Italsat regenerative downlink performance, nondisruptive group delay and amplitude measurement, the Polar Platform of the Space Shuttle, EVA tasks and services, fault diagnosis, and an autonomous power system test bed. Topics discussed include space debris and manned space operations, data transport and command management services for the Space Station, a thermodynamic approach to data processor analysis, anomaly detection and resolution system, the Telemetry, Timing, Command, and Control system, the Space Construction Shuttle Flight experiment, and structural analysis of the Space Shuttle propulsion components. Consideration is given to electrostatic charging and arc discharges on satellite dielectrics, the attitude control system of the IUE, orbital acceleration, spaceborne distributed aperture/coherent array processing, the propulsion module for the Columbus Space Platform, the next-generation STS, trajectory performance evaluation, the Hubble Space Telescope, a linear quadratic tracker for control moment gyro based attitude control of the Space Station, and existing satellite systems and networks. I.F.

A86-40585#
ADVANCED EVA OPERATION ON-ORBIT TASKS AND SERVICES
F. J. ABELES and R. H. SCHAEFER (Grumman Corp., Bethpage, NY) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 60-68.
(AIAA PAPER 86-1175)

Methods for improving astronauts' productivity during extravehicular activity (EVA) are described. EVA operations involve construction, servicing, and maintenance of the Space Shuttle and servicing and maintenance of the Shuttle's payloads. EVA cycle tasks must be performed in the proper sequence and it is estimated that an astronaut can perform up to 6.5 hrs of EVA productive work during one EVA and a maximum of 19.5 hrs of EVA productive work per astronaut can be accomplished in a week. The utilization of dedicated work stations, a dedicated translation system, properly designed equipment, and job performance aids, such as the helmet mounted display (HMD), to increase EVA productive time is studied. The function and advantages of the HMD are examined. The need to consider the astronaut's comfort during performance of EVA tasks is discussed. I.F.

A86-40588#
THE IMPACT OF SPACE DEBRIS ON MANNED SPACE OPERATIONS
L. P. TEMPLE, III (DOD, Space Operations Committee, Washington, DC) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 85-90. refs
(AIAA PAPER 86-1178)

The effects of space debris on manned space activities are investigated. The probability of collisions of man-sized objects or large-scale structures with space debris is estimated; it is determined that the probability of a man-sized object receiving an impact from space debris is 1000-10000; however, for large structures the potential for impact is greater, and the structures must be designed with this consideration. The rate of debris increase which is dependent on collisions between space objects and additions due to normal operations is examined. Pit densities observed in Skylab windows and Space Shuttle flights are compared; the densities observed from Skylab are 0.1/sq cm after 84 days of exposure and 10 years later the Shuttle recorded 100-200/sq cm of debris after 7-8 days in space. It is noted that though debris is not a current problem standardized operating procedures and equipment need to be developed in order to minimize the amount of debris in space. I.F.

A86-41978* National Aeronautics and Space Administration, Washington, D.C.
BUSINESS IN ORBIT - THE COMMERCIAL USE OF SPACE
I. T. GILLAM, IV (NASA, Washington, DC) Journal of International Affairs (ISSN 0022-197X), vol. 39, Summer 1985, p. 115-120.

Current and proposed business opportunities in space are discussed. The advantages offered by the zero gravity environment of space are examined. The roles of the Space Shuttle and the Space Station in space commercialization are described. International development and use of the Space Station is proposed. It is observed that the communications satellite industry is a successful space venture, and opportunities for materials processing and pharmaceuticals production in space are considered. The relationship between NASA's Office of Commercial Programs, which assists businesses in space commercialization, and industry is studied. The impact of space commercialization on the national economy and international trade is analyzed. I.F.

A86-41982
EXPECTATIONS IN SPACE LAW - A PEEK INTO THE FUTURE
S. GOROVE (Mississippi, University, University) Journal of International Affairs (ISSN 0022-197X), vol. 39, Summer 1985, p. 167-174. refs

Legal concerns related to the Space Station and human settlements in free space and celestial bodies, solar power satellites, the geostationary orbit, direct broadcast satellites, and remote sensing are discussed. The issues of interparty and third party liability, the registration of the Space Station, and jurisdiction, supervision, and control of the Space Station are examined. The need for laws for human conduct in space and the prohibiting of space resources exploitation is described. Questions related to national versus international authority are considered. The proposed use of solar power satellites to generate energy will result in problems related to the impact of the transmission on the earth's environment, potential interference with other radio transmissions, and access to GEO for power transfer. Problems with the free dissemination of remote sensing data and prior consent for direct satellite broadcasting are studied. I.F.

A86-42236
DEVELOPING THE FINAL FRONTIER: INTERNATIONAL COOPERATION IN THE PEACEFUL USES OF OUTER SPACE
A. FLORINI Research supported by the James S. McDonnell Foundation, Armand Hammer Foundation, and Carnegie Corp. New York, United Nations Association of the United States of America, Inc., 1985, 79 p.

This history and law of human activity in outer space is examined, current space programs are reviewed, and the major policy issues facing the U.S. and the world are outlined. The launching of Sputnik is discussed as well as the formation of NASA, the race to the moon, the Apollo-Soyuz Test Project, the Outer Space Treaty and the Moon Treaty. NASA's Space Shuttles are considered as well as U.S. scientific aspirations in space; the Salyut space stations; ESA's Ariane, Spacelab, and EURECA projects; and the space programs of Japan, China, India, and Canada. A treatment is provided of the Space Station from the point of view of international cooperation and the military. The militarization of outer space is discussed, with particular emphasis on antisatellite systems and 'SDI'. Multilateral initiatives are also outlined. K.K.

A86-42743#
ORBITAL CONSUMABLES RESUPPLY REQUIREMENTS IMPACT ON THE EVOLUTION OF OSCRS
D. L. PERRY and R. BEMIS (Rockwell International Corp., Downey, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1603)

Development of the Orbital Spacecraft Consumables Resupply System (OSCRS) is an essential and logical step in the progression of man's utilization of space. Present and future space assets that would benefit from resupply provide specific design-related requirements. These requirements integrated with the role OSCRS will play in the industrialization of space provide an optimized utilitarian vehicle. Specific requirements and their impact on OSCRS design include the potential user resupply requirements and mission scenarios, unique user spacecraft handling needs and other OSCRS uses, and the accompanying integration concerns. These and other elements and their effect on the evolution of an OSCRS design are discussed. The paper closes with a focus on the influence the bipropellant resupply scenario has on the design and development of the generic resupply tanker. Author

A86-42993* California Univ., Los Angeles.
COMPUTER AIDED MODELLING/COMPENSATOR DESIGN FOR A FLEXIBLE SPACE ANTENNA
J. S. GIBSON and D. L. MINGORI (California, University, Los Angles) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1788-1793. refs
(Contract NAS7-918)

Controller design algorithms are developed to produce simultaneously both a model of the plant and a compensator. The size of the model and properties of the compensator are driven by the performance requirements, the disturbance environment, and the location, number and type of sensors and actuators. The procedure is based on linear optimal control theory

for distributed systems, and balanced realization theory is used to guide the development of the model and reduce the order of the compensator. Author

A86-43201
ASTRODYNAMICS 1985; PROCEEDINGS OF THE CONFERENCE, VAIL, CO, AUGUST 12-15, 1985. PARTS 1 & 2
B. KAUFMAN, ED. (U.S. Navy, Naval Research Laboratory, Washington, DC), J. J. F. LIU, ED., F. R. HOOTS, ED. (USAF, Space Command, Peterson AFB, CO), and R. A. CALICO, ED. (USAF, Institute of Technology, Wright-Patterson AFB, OH) Conference sponsored by AAS and AIAA. San Diego, CA, Univelt, Inc. , 1986. Pt. 1, 785 p.; pt. 2, 745 p. For individual items see A86-43202 to A86-43253, A86-43255 to A86-43278.

Papers are presented on the age and stability of the solar system, orbit dynamics, transfer dynamics, attitude dynamics and control, optimal control, and control and identification of large space structures. Topics discussed include platform servicing, mission design, and control for the 1990's, platform configurations, mission designs and applications, and atmospheric density at satellite altitudes. Consideration is given to estimating the Extreme Ultraviolet Explorer sky survey exposure, a fiber-optic laser velocimeter for studying unsteady rotating flows in spinning rocket motors, nonlinear feedback control for remote orbital capture, orbit evolution and ion cloud releases, collision-induced and explosion-induced satellite breakups, and the transfer of asteroidal material to earth orbit by means of gravity assist trajectories. Emphasis is placed on celestial mechanics, geosynchronous satellite orbits, orbit determination and maneuvers, orbit determination using TDRSS and the GPS, interplanetary exploration, and planetary exploration. I.F.

A86-43204
ORBIT TRANSFER ERROR ANALYSIS FOR MULTIPLE FINITE PERIGEE BURN, ASCENT TRAJECTORIES
N. J. ADAMS (Charles Stark Draper Laboratory, Inc., Cambridge, MA) and R. G. MELTON (Pennsylvania State University, University Park) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 37-56. refs
(AAS PAPER 85-302)

A new algorithm has been developed which calculates the propagation of guidance and navigation errors along a nominal trajectory involving finite-duration perigee burns. A numerical simulation of a transfer from low earth orbit to geostationary orbit (including finite-duration burns, coast phases, impulsive trim burns, and an impulsive plane change and circularization burn at apogee) serves to demonstrate the applications of the algorithm. This example also indicates the effects of mid-course corrections on the final errors at apogee. Author

A86-43230
EURECA CONCEPT AND ITS POTENTIAL EVOLUTION WITHIN THE SPACE STATION ERA
R. L. MORY (ESA, Paris, France) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 551-568.
(AAS PAPER 85-398)

The development and project objectives of the EURECA concept are presented as well as the design approach, system capabilities and the first mission payload. An account of EURECA's adaptation for nonmicrogravity missions is given together with its role in the Space Station and Columbus scenarios. The EURECA platform will be deployed from the Shuttle cargo bay in-orbit, will operate in a free-flying mode for about six months, and will then be retrieved, returned to earth (by a subsequent Orbiter) and prepared for the next mission. It is noted that this carrier provides all essential services so that the development of a special satellite is not necessary. Moreover, as a potential autonomous payload carrier within the future Space Station, it could accommodate and operate space instruments either in the free-flying or docked modes. It is concluded that the role EURECA will play in the Space Station scenario will be governed by the results of on-going studies and by negotiations with NASA. K.K.

A86-43274* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GALILEO INFLIGHT FRICTION IDENTIFICATION FOR THE SCAN PLATFORM CONTROL LOOP
G. D. IANCULESCU and G. K. MAN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 2 . San Diego, CA, Univelt, Inc., 1986, p. 1373-1391. NASA-supported research. refs
(AAS PAPER 85-383)

Two types of friction identification algorithms (position-based and rate-based) are investigated in an attempt to better understand cone actuator inflight behavior in the Galileo scan platform pointing system. This investigation involves the measurement of the scan platform position (or rate) with respect to the stator following a platform slew maneuver. Inflight data collection by the spacecraft's sensors and subsequent ground-based data processing comprise the two major steps in the identification experiment. The proposed algorithms were capable of obtaining friction estimates within + or - 10 percent accuracy; hence, it is concluded that this inflight system identification technique can sufficiently tune the Galileo cone controller. K.K.

A86-43335
SPACE STATIONS: LEGAL ASPECTS OF SCIENTIFIC AND COMMERCIAL USE IN A FRAMEWORK OF TRANSATLANTIC COOPERATION; PROCEEDINGS OF THE INTERNATIONAL COLLOQUIUM, HAMBURG, WEST GERMANY, OCTOBER 3, 4, 1984
K.-H. BOECKSTIEGEL, ED. (Koeln, Universitaet, Cologne, West Germany) Colloquium organized by the Universitaet Koeln and DGLR; Supported by BMFT. Cologne, West Germany, Carl Heymanns Verlag (Schriften zum Luft- und Weltraumrecht. Volume 5), 1985, 262 p. In English and German. For individual items see A86-43336 to A86-43350.

Amerian experiences and perspectives regarding an international coperation on a permanently manned space station are considered along with European experience and perspectives, the relevance of general multilateral space conventions to space stations, possible models for specific space agreements, agreements between States and with International Organizations, and contracts of and with private enterprises concerning the development, the construction, and the assembly of space vehicles. Attention is given to contractual and related agreements required for a satellite launch, applicable law and dispute settlement, forms of coverage and current market situation in the case of insurance, state supervision and registration, and legal questions which need to be addressed in the case of the Space Station. Other questions explored are related to legal aspects of stations in space, space stations and the law concerning intellectual property, aspects of law and practice in the U.S., and the experience of the European Space Agency. G.R.

A86-43336
EUROPEAN EXPERIENCE AND PERSPECTIVES [EUROPAEISCHE ERFAHRUNGEN UND PERSPEKTIVEN]
G. GREGER (BMFT, Bonn, West Germany) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 17-25. In German.

The history of the cooperation between the U.S. and Europe, in particular West Germany, with respect to space-related activities is examined, taking into account the beginning of this cooperation in 1964, the cooperative satellite projects Azur and Aeros, Spacelab, and the American offer regarding a participation of other countries in the Space Station project. The form and the results of this cooperation were generally satisfactory for European partners. However, there were and are also some difficulties. One

problem is related to the launching services provided by the U.S., giving attention to a complaint of an American aerospace company, claiming the violation of one of its patents. Difficulties can arise, in particular, in connection with the economic utilization of space-related activities and the competition of private firms. Attention is given to the European trend to autonomy, possible obstacles to technology transfer, problems related to U.S. laws, and the Space Station as a challenge. G.R.

A86-43701
SPACECOM '85; SPACE AND RADIOCOMMUNICATIONS SYMPOSIUM, 5TH, PARIS AND LE BOURGET, FRANCE, JUNE 5-7, 1985, SPEAKERS' PAPERS
Symposium organized by ITU and Direction Generale des Telecommunications. Geneva, Switzerland, International Telecommunication Union, 1985, 232 p. In English and French. For individual items see A86-43702 to A86-43718.

Papers are presented on future space transportation systems, space platforms and launchers, telecommunications satellite designs, and the Olympus spacecraft. The application of direct television satellite broadcasting, advanced satellite communication systems, Telecom 1, and radio determination satellite service to aeronautical and land functions is discussed. Consideration given to orbit utilization by different services, the effect of earth stations on orbit utilization, and access for satellites of the fixed-satellite service to orbit and spectrum. Topics related to technology transfer and training, the cost and benefits of international space meteorology programs, the use of the global distress system to provide for sea safety, remote sensing, and collaboration and cooperation between governments and industry on a regional level are examined. I.F.

A86-44326
SPACE SAFETY AND RESCUE 1984-1985
G. W. HEATH, ED. (SAR-assist, Inc., Greenwich, CT) San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 64), 1986, 400 p. For individual items see A86-44327 to A86-44333.

The present conference on spacecraft crew safety and rescue technologies and operations considers safety aspects of Space Shuttle ground processing, the Inmarsat and COSPAS/SARSAT emergency location satellite systems, emergency location and rescue communications using Geosat, the use of the Manned Maneuvering Unit for on-orbit rescue operations, NASA Space Station safety design and operational considerations, and the medico-legal implications of space station operation. Also discussed are the operational and environmental aspects of EPIRBS, mobile satellites for safety and disaster response, Inmarsat's role in the Future Global Maritime Distress and Safety System, and test results of the L-band satellite's EPIRB system. O.C.

A86-44526
SPACE - TECHNOLOGY AND OPPORTUNITY; PROCEEDINGS OF THE CONFERENCE, GENEVA, SWITZERLAND, MAY 28-30, 1985
Pinner, England, Online Publications, 1985, 356 p. For individual items see A86-44527 to A86-44551.

The technologies, organizations, hardware and plans for the commercialization of space activities in the near future are detailed. Financing schemes for manufacturing, leasing, sharing, or owning all or part of a spacecraft or a potential space-based industrial process are delineated, along with the problems facing the space insurance business. Although emphasis is placed on ESA and other European programs, the NASA Manned Space Station plays a pivotal role in the space development plans of most western nations, experimenters, and corporations. Attention is also devoted to unmanned platforms, their potential commercial applications, and to the necessary hardware infrastructure to support their operations. The capabilities of the Ariane 5 launch vehicle, the Hermes space plane, and a series of Chinese launch vehicles are described. Comparisons are made of the economics of various types of partially and fully reusable launch vehicles with diverse payload capabilities, of which the STS has the largest capacity. M.S.K.

A86-45626
COLUMBUS I; PROCEEDINGS OF THE FIRST COLUMBUS WORKSHOP UTILIZATION ASPECTS, CAPRI, ITALY, JUNE 17-21, 1985
Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, 156 p. For individual items see A86-45627 to A86-45651.

The directions being taken in the development of the European Columbus pressurized module for the NASA Manned Space Station (MSS) are explored. Attention is given to the distribution of work among the participating nations on the basis of funding contributions, and to previous space research by the same countries, particularly in the Spacelab missions. The Phase B studies will lead to a final definition of the module design, its interfaces with the rest of the MSS, the instrumental and experimental payloads, and avenues for future expansion. ESA plans for a parallel development of an autonomous capability, including another pressurized module, the Hermes space plane, an unmanned service vehicle and a data relay satellite, are described. Details of the experimental goals and hardware prototypes for future experiments in fluid physics, biology, materials processing, and tethered satellite applications are presented. Finally, possible configurations of the polar and co-orbiting unmanned platform elements of the MSS program are discussed. M.S.K.

A86-46808
DISTRIBUTED PARAMETER SYSTEMS; PROCEEDINGS OF THE SECOND INTERNATIONAL CONFERENCE ON CONTROL THEORY FOR DISTRIBUTED PARAMETER SYSTEMS AND APPLICATIONS, VORAU, AUSTRIA, JULY 9-14, 1984
F. KAPPEL, ED., W. SCHAPPACHER, ED. (Graz, Universitaet, Austria), and K. KUNISCH, ED. (Graz, Technische Universitaet, Austria) Conference sponsored by BMFWF. Berlin and New York, Springer-Verlag (Lecture Notes in Control and Information Sciences, Volume 75), 1985, 470 p. For individual items see A86-46809 to A86-46816.

Papers are presented on a variational approach to parameter estimation; fixed point methods in nonlinear control; an initial value control problem for Burgers' equation; control of retarded Lienard equations; the identification of a spatially varying coefficient in a parabolic partial differential equation; disturbance decoupling for distributed systems; the Riccati equation with unbounded coefficients; shape optimal designs for communications satellites; and distributed parameters in porous media flow. Topics discussed include the maximum principle for nonlinear, nonconvex systems and of distributed parameter systems with time lags; the optimal control of non-well-posed systems; the Legendre-Tau approximation for functional differential equations; time-minimal control problems; the approximation of Riccati equations corresponding to hyperbolic boundary control problems; an interconnected distributed parameter system; the tandem connection of systems with delays; distributed vibratory systems; and an infinite dimensional system with unbounded control and observation. Consideration is given to coefficient identification for a parabolic problem, theorems for a stochastic system with Poisson jumps; the differential stability of control-constrained optimal control problem; the stability properties of a hyperbolic damped wave equation; continuous time programming without differentiability; and shape stabilization of flexible structures. I.F.

A86-46851* Louisiana State Univ., Baton Rouge.
WORKSHOP ON COSMIC RAY AND HIGH ENERGY GAMMA RAY EXPERIMENTS FOR THE SPACE STATION ERA, LOUISIANA STATE UNIVERSITY, BATON ROUGE, OCTOBER 17-20, 1984, PROCEEDINGS
W. V. JONES, ED. and J. P. WEFEL, ED. (Louisiana State University, Baton Rouge) Workshop sponsored by the Louisiana State University, Martin Marietta Corp., NASA, and NSF. Baton Rouge, LA, Louisiana State University, 1985, 575 p. For individual items see A86-46852 to A86-46899.

The potential of the Space Station as a platform for cosmic-ray and high-energy gamma-ray astronomy is discussed in reviews, reports, and specific proposals. Topics examined include antiparticles and electrons, science facilities and new technology, high-energy nuclear interactions, nuclear composition and energy spectra, Space Shuttle experiments, Space Station facilities and detectors, high-energy gamma rays, and gamma-ray facilities and techniques. Consideration is given to universal-baryon-symmetry testing on the scale of galactic clusters, particle studies in a high-inclination orbit, balloon-borne emulsion-chamber results on ultrarelativistic nucleus-nucleus interactions, ionization states of low-energy cosmic rays, a large gamma-ray telescope for point-source studies above 1 GeV, and the possible existence of stable quark matter. T.K.

A86-46855
EXTERNAL TANK/AFT CARGO CARRIER ON ORBIT APPLICATIONS
T. MOBLEY and P. MITCHELL (Martin Marietta Corp., New Orleans, LA) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 83-92.

The use of the Space Shuttle external tank (ET) and aft cargo carrier (ACC) as orbital-platform structures is proposed. The ET and ACC are described; the relatively low cost of orbiting the ET rather than discarding it is indicated; and a basic orbital-platform design using the ET as strongback for payloads and an ACC module to provide utilities is presented. Consideration is given to a large-area gamma-ray telescope of gas-Cerenkov type (installed in the ET on orbit by EVA) and a solar furnace capable of melting the ET for use as an on-orbit materials resource. Photographs, drawings, diagrams, and graphs are provided. T.K.

A86-46942#
ZERO-G SIMULATION VERIFIES EVA SERVICING OF SPACE STATION MODULES
B. N. GRIFFIN (Boeing Aerospace Co., Huntsville, AL) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 6 p.
(AIAA PAPER 86-2312)

The Space Station accommodations required for on orbit zero-g maintenance and repair were evaluated during two months of neutral buoyancy testing. Boeing, in a joint effort with NASA, used Shuttle-type pressure suits and the simulated weightlessness provided by neutral buoyancy to assess four areas of hardware and operations. These included: (1) Space Station System Architecture; (2) Common Module Exterior; (3) Common Module Interior; and (4) Voice-Activated Systems. Specifically, the tests focused on servicing debris shield/body-mounted radiator panels, replacement of thermal blankets or Multi-Layer insulation and repair techniques for debris damage. Design engineers and astronauts participated as pressure-suited test subjects in evaluation of a broad range of concept options. The significant findings for these tests are: (1) the astronaut positioning arm is one of the most useful tools for Space Station EVA operations; (2) the minimum separation between modules should be 78 inches; (3) axial debris panels were preferred over circumferential; (4) on-orbit repair techniques for debris-damaged modules were effective; and (5) voice-activated systems are ideal for EVA. Improved suit communications, however, are required for implementation.
Author

A86-47292
INTERNATIONAL AEROSPACE AND GROUND CONFERENCE ON LIGHTNING AND STATIC ELECTRICITY, 10TH, AND CONGRES INTERNATIONAL AERONAUTIQUE, 17TH, PARIS, FRANCE, JUNE 10-13, 1985, PROCEEDINGS
Conference and Congress organized by the Association Aeronautique et Astronautique de France; Sponsored by the Delegation Generale pour l'Armement, CNES, U.S. Army, et al. Les Ulis, France, Les Editions de Physique, 1985, 527 p. For individual items see A86-47293 to A86-47338.

The conference presents papers on statistical data and standards, coupling and indirect effects, meteorology and thunderstorm studies, lightning simulators, fuel ignition hazards, the phenomenology and characterization of lightning, susceptibility and protection of avionics, ground systems protection, lightning locators, aircraft systems protection, structures and materials, electrostatics, and spacecraft protection against static electricity. Particular attention is given to a comparison of published HEMP and natural lightning on the surface of an aircraft, electromagnetic interaction of external impulse fields with aircraft, of thunderstorm currents and lightning charges at the NASA Kennedy Space Center, the design of a fast risetime lightning generator, lightning simulation tests in FAA CV-580 lightning research aircraft, and the energy requirements of an aircraft triggered discharge. Papers are also presented on aircraft lightning attachment at low altitudes, a new form of transient suppressor, a proving ground for lightning research, and a spacecraft materials test in a continuous, broad energy-spectrum electron beam. K.K.

A86-47401
GUIDANCE, NAVIGATION AND CONTROL CONFERENCE, WILLIAMSBURG, VA, AUGUST 18-20, 1986, TECHNICAL PAPERS
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1986, 983 p. For individual items see A86-47402 to A86-47509.

Recent developments in navigation, guidance, and control technology are discussed in reviews and reports, with an emphasis on aeronautical and space applications. Topics examined include flight-management systems for commercial jets, nonlinear adaptive control of an elastic robotic arm, the Space Telescope precision-pointing control system, spin-axis controllers for GEO satellites, dynamics and control of slew maneuvers of a large flexible spacecraft, and multicriterion approaches to optimization of linear regulators. Consideration is given to the effect of time delay on flying qualities, laser feedback controls for passive ring-laser gyros, eigensystem synthesis for active flutter suppression on an oblique-wing aircraft, terminal control factors for the carrier landing task, and a linear-quadratic guidance law for solid-fuel space-based interceptors. T.K.

A86-47648#
THE U.S. CIVIL SPACE PROGRAM: A REVIEW OF THE MAJOR ISSUES REPORT OF AN AIAA WORKSHOP, ALEXANDRIA, VA, JULY 22, 23, 1986
New York, American Institute of Aeronautics and Astronautics, 1986, 85 p. refs

Urgent and long-term issues affecting the U.S. civil space program are defined and recommendations are made. These issues include: (1) access to space (i.e., Shuttle redesign and requalification, launch and spacecraft insurance, and new launcher development); (2) space program management (ie., budget rationale and implementation, NASA's relation to other agencies, and military-civil interaction); (3) international involvement (ie., interactional civil space leadership, international cooperation and competition and international space year 1992); and (4) human motivations, resources and perceptions. It is noted that U.S. leadership in space can be restored only by vigorous action backed by firm commitments. The first requirement is a unified national policy which sets along terms objectives, and the second is a civil space budget which is approximately double what it is at the present time. K.K.

A86-47901
ASTRODYNAMICS CONFERENCE, WILLIAMSBURG, VA, AUGUST 18-20, 1986, TECHNICAL PAPERS
Conference sponsored by AIAA and AAS. New York, American Institute of Aeronautics and Astronautics, 1986, 413 p. For individual items see A86-47902 to A86-47944.

Various papers on satellite and planetary mission dynamics are presented. Individual topics discussed include: orbital motion in the frequency domain, the Galileo orbital tour for the 1986 launch opportunity, circulating transportation orbits between earth and Mars, optimum burn scheduling for low-thrust orbital transfers, comparison of nonlinear filters for orbit determination, common period four-satellite continuous global coverage, motion of a drag-free experiment on the Space Station, and engineering improvements, sequencing and orbital determination for Voyager 2 Uranus encounter. Also considered are: approach strategy for rendezvous with Comet Tempel 2, maneuver strategies for Magellan Mission, Jupiter Polar Orbiter Mission concepts, modelling and simulation of Spacecraft Solar Array deployment, sensitivity analysis for lunar trajectories, maximum likelihood estimation for orbit determination, adaptive estimation for an accelerating spacecraft, Slinger in-orbit booster facility, simulation of satellite breakups, missile launch windows of avoiding collisions with satellites, linear-quadratic stationkeeping for the STS Orbiter. C.D.

A86-47931*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE SLINGER - AN IN-ORBIT BOOSTER FACILITY
R. M. MULLER (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 298-302.
(AIAA PAPER 86-2175)

The Slinger, a permanent facility that can be built and stationed in a low earth orbit and can reduce the cost of transporting satellites into geostationary orbit by a factor of three, is examined. The Slinger is described, giving its size, mass, capacity, and the construction of its tethers. Techniques for accelerating the tethers are discussed. The operation of the Slinger is examined, including its launching of a payload into geostationary transfer orbit (GTO) and its return to lower orbit. The Slinger's cycle time, its handling of lighter GTO payloads, and the effects of orbital precession and drag are briefly discussed. A possible reusable second stage based at the Slinger is discussed, and missions involving higher velocity and heavier payloads that can be helped by the Slinger are briefly considered along with the use of the Slinger to provide astronauts with 1 g and the use of a Slinger on the moon. C.D.

A86-49597*# Boeing Aerospace Co., Seattle, Wash.
A STEERABLE RADIATOR FOR SPACECRAFT APPLICATION
B. L. HEIZER, S. D. GOO, G. D. RHODES, D. W. THORESON (Boeing Aerospace Co., Seattle, WA), and R. C. PARISH (NASA, Johnson Space Center, Houston, TX) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 7 p.
(Contract NAS9-17310)
(AIAA PAPER 86-1298)

Future large space structures such as the Space Station will have high dissipation and long life requirements which dictate the requirements for steerable radiators. Several rotary coupling concepts were considered to accomplish heat transport across the steerable radiator system's rotating interface. Rotary fluid couplings were chosen over rotary contact couplings or flexible lines because of low temperature gradients and operational flexibility. A rotary fluid coupling has been designed for use on initial operating capability (IOC) and growth Space Station. Its internal seals have been demonstrated to a 10 year life with minimal (0.055 lbm NH3/year) leakage between internal passages. Materials compatibility tests have been conducted to demonstrate compatibility with ammonia. A seal leakage management system has been designed to: (1) monitor pressures between the internal seals, (2) remove leakage, and (3) store the leakage fluid in a reservoir. Author

A86-50334
TOWARDS COLUMBUS AND SPACE STATION; PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM, BONN, WEST GERMANY, OCTOBER 2-4, 1985
Symposium organized by DGLR; Sponsored by AAS, AIAA, BMFT, et al. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, 384 p. For individual items see A86-50335 to A86-50340.
(DGLR BERICHT 85-03)

The progress made in ESA design and other work on the development of the Columbus segment and other ESA contributions to the NASA Space Station project as of October 1985 is summarized. The discussions are performed from technology synthesis, utilization, program and schedule, and user requirements points of view. Design decisions and technological developments necessary to realize the attached Columbus module and the associated free-flying platforms, either co- or polar-orbiting, are delineated. Attention is given to power system, data management system and other hardware systems which have been selected for Columbus, along with possible evolutions to meet future Space Station or autonomous European space station requirements. Finally, design schedules and project milestones which have been or must still be met are described. M.S.K.

N86-24217*# Essex Corp., Huntsville, Ala. Space Systems Group.
THE SYSTEM INTEGRATION AND VERIFICATION TESTING OF AN ORBITAL MANEUVERING VEHICLE FOR AN AIR BEARING FLOOR Final Report
N. L. SHIELDS, JR., M. F. MARTIN, K. R. PAULUKAITIS, J. W. HASLAM, JR., and D. E. HENDERSON 22 Feb. 1986 125 p refs
(Contract NAS8-35636)
(NASA-CR-178350; NAS 1.26:178350; H-86-02) Avail: NTIS HC A06/MF A01 CSCL 05H

The teleoperator and Robotics Evaluation Facility (TOREF) is composed of a 4,000 square foot precision air bearing floor, the Teleoperator Motion Base, the Target Motion and Support Simulator, the mock-ups of the Hubble Space Telescope, Multi-mission Modular Spacecraft, and the Orbital Maneuvering Vehicle (OMV). The TOREF and its general capabilities to support the OMV and other remote system simulations; the facility operating procedures and requirements; and the results of generic OMV investigations are summarized. B.G.

N86-24536*# Alabama Univ., Birmingham. Dept. of Computer and Information Science.
MACHINE VISION AND THE OMV
M. A. MCANULTY *In* NASA. Marshall Space Flight Center Research Reports: 1985 NASA/ASEE Summer Faculty Fellowship Program 24 p Jan. 1986 refs
Avail: NTIS HC A99/MF E04 CSCL 09B

The orbital Maneuvering Vehicle (OMV) is intended to close with orbiting targets for relocation or servicing. It will be controlled via video signals and thruster activation based upon Earth or space station directives. A human operator is squarely in the middle of the control loop for close work. Without directly addressing future, more autonomous versions of a remote servicer, several techniques that will doubtless be important in a future increase of autonomy also have some direct application to the current situation, particularly in the area of image enhancement and predictive analysis. Several techniques are presentet, and some few have been implemented, which support a machine vision capability proposed to be adequate for detection, recognition, and tracking. Once feasibly implemented, they must then be further modified to operate together in real time. This may be achieved by two courses, the use of an array processor and some initial steps toward data reduction. The methodology or adapting to a vector architecture is discussed in preliminary form, and a highly tentative rationale for data reduction at the front end is also discussed. As a

by-product, a working implementation of the most advanced graphic display technique, ray-casting, is described. Author

N86-24537*# Berry Coll., Mount Berry, Ga. Dept. of Physics.
A STUDY OF 35-GHZ RADAR-ASSISTED ORBITAL MANEUVERING VEHICLE/SPACE TELESCOPE DOCKING
M. W. MCDONALD *In* NASA. Marshall Space Flight Center Research Reports: 1985 NASA/ASEE Summer Faculty Fellowship Program 31 p Jan. 1986 refs
Avail: NTIS HC A99/MF E04 CSCL 22A

An experiment was conducted to study the effects of measuring range and range rate information from a complex radar target (a one-third scale model of the Edwin P. Hubble Space Telescope). The radar ranging system was a 35-GHz frequency-modulated continuous wave unit developed in the Communication Systems Branch of the Information and Electronic Systems Laboratory at Marshall Space Flight Center. Measurements were made over radar-to-target distances of 5 meters to 15 meters to simulate the close distance realized in the final stages of space vehicle docking. The Space Telescope model target was driven by an antenna positioner through a range of azimuth and elevation (pitch) angles to present a variety of visual aspects of the aft end to the radar. Measurements were obtained with and without a cube corner reflector mounted in the center of the aft end of the model. The results indicate that range and range rate measurements are performed significantly more accurately with the cooperative radar reflector affixed. The results further reveal that range rate (velocity) can be measured accurately enough to support the required soft docking with the Space Telescope. Author

N86-24711 National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION SYSTEMS: A BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 1)
Mar. 1986 158 p
(NASA-SP-7056(01); NAS 1.21:7056(01)) Avail: NTIS HC A07 CSCL 22A

This bibliography lists 624 reports, articles, and other documents introduced into the NASA scientic and technical information system between January 1, 1985 and June 30, 1985. Its purpose is to provide helpful information to the researcher, manager, and designer in technology development and mission design according to system, interactive analysis and design, structural and thermal analysis and design, structural concepts and control systems, electronics, advanced materials, assembly concepts, propulsion, and solar power satellite systems. The coverage includes documents that define major systems and subsystems, servicing and support requirements, procedures and operations, and missions for the current and future Space Station. Author

N86-24736*# National Aeronautics and Space Administration, Washington, D.C.
SPACECRAFT ARCHITECTURE
V. V. ZEFELD Mar. 1986 9 p refs Transl. into ENGLISH from Arkhitektura Kosmicheskikh Obyektov (Moscow, USSR), Nauka, 1977 p 187-191 Original language doc. was announced in IAA as A78-13592 Transl. by SCITRAN, Inc., Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-77908; NAS 1.15:77908) Avail: NTIS HC A02/MF A01 CSCL 22B

Three requirements for a spacecraft interior are considered. Adequate motor activity in the anatomical-physiological sense results from attention to the anthropometric characteristics of humans. Analysis of work requirements is a prerequisite for the planning of adequate performance space. The requirements for cognitive activity are also elucidated. The importance of a well-designed interior during a long space flight is discussed. Author

N86-24741# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
A PROPOSED DESIGN FOR AN INTERIM SPACE RESCUE FERRY VEHICLE M.S. Thesis
J. D. HALSELL, JR. Dec. 1985 211 p refs
(AD-A164039; AFIT/GSO/ENY/85D-2) Avail: NTIS HC A10/MF A01 CSCL 22B

This investigation proposed a method of connecting the Personnel Rescue Enclosure to the Manned Maneuvering Unit using a modified flight-qualified hardware item the Apogee Kick Motor Capture Device. The resulting configuration is an immediately available but non-optimum vehicle for transferring stranded astronauts housed within Personnel Rescue Enclosures from a rotating stranded spacecraft to a nearby rescue spacecraft. The flying qualities of this Interim Rescue Vehicle (IRV) were simulated using an existing NASA spaceflight simulation computer program. The results showed that the Manned Maneuvering Unit's control system was capable of limiting uncommanded IRV rotations to within the control law deadbands during all simulated maneuvers and in all control modes except during transverse translations in the backup control mode. The IRV's increased mass and increased center-of-mass/center-of-thrust offset significantly degraded acceleration capability and specific propellant consumption. Plume impingement however was found to be of minor importance. The satellite stabilization mode was found to have significant rotational-to-translational coupling which made it undesirable for IRV use. Finally procedures were outlined for using the IRV in an orbiter-to-orbiter rescue scenario. Author (GRA)

N86-25791* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LATCHING MECHANISM FOR DEPLOYABLE/RE-STOWABLE COLUMNS USEFUL IN SATELLITE CONSTRUCTION Patent
E. L. AHL, JR., inventor (to NASA) 6 May 1986 11 p Filed 2 May 1984 Supersedes N84-25063 Sponsored by NASA
(NASA-CASE-LAR-13169-1; US-PATENT-4,587,526; US-PATENT-APPL-SN-606431; US-PATENT-CLASS-343-883; US-PATENT-CLASS-343-DIG.2; US-PATENT-CLASS-52-110)
Avail: US Patent and Trademark Office CSCL 13I

A column longeron latch assembly provides the securing mechanism for the deployable, telescoping column of a hoop/column antenna. The column is an open lattice structure with three longerons disposed 120 deg apart as the principle load bearing member. The column is deployed from a pair of eleven nested bays disposed on opposite sides of a center section under the influence of a motor-cable-pulley system. The longeron latch is a four bar linkage mechanism using the over-center principle for automatically locking the longeron sections into position during deployment. The latch is unlocked when the antenna is to be restowed. A spring pack disposed in the end of each longeron serves to absorb stress forces on the deployed column through the cam head piston and abutting latch from an adjacent longeron.
Official Gazette of the U.S. Patent and Trademark Office

N86-25794*# National Aeronautics and Space Administration, Washington, D.C.
PROCEEDINGS OF A WORKSHOP ON APPLICATIONS OF TETHERS IN SPACE: EXECUTIVE SUMMARY
W. A. BARACAT, Compiler 1986 43 p Proc. held in Venice, Italy, 15-17 Oct. 1985
(Contract NASW-3921)
(NASA-CP-2422; NAS 1.55:2422) Avail: NTIS HC A03/MF A01 CSCL 13I

The workshop was attended by persons from government, industry, and academic institutions to discuss the rapidly evolving area of tether applications in space. Many new applications were presented at the workshop, and existing applications were revised, refined, and prioritized as to which applications should be implemented and when. The workshop concluded with summaries developed individually and jointly by each of the applications panels. Author

N86-26650*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
INDEX OF AEROSPACE MECHANISMS SYMPOSIA PROCEEDINGS 1-19
A. RINALDO (Lockheed Missiles and Space Co., Sunnyvale, Calif.) and J. WILSON Apr. 1986 281 p
(NASA-TM-88205; A-86076; NAS 1.15:88205) Avail: NTIS HC A13/MF A01 CSCL 13I

This index, organized in five sections (by symposium, by title, by author, by subject, and by project), brings together information on the first 19 Aerospace Mechanisms symposia. Key words are included, cross-referencing all the symposia, and the eighteenth and nineteenth symposia are cross-indexed by project. The Aerospace Mechanisms symposia are devoted to discussions of design, fabrication, test, and operational use of aerospace mechanisms; this is the first index that compiles information on symposia held from 1966 through 1985. Author

N86-27300*# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Eng.
SPACE MANUFACTURING UTILIZING THE DIRECTIONAL ELECTROSTATIC ACCRETION PROCESS
A. MORTENSEN *In* NASA. Goddard Space Flight Center The 1985 Get Away Special Experimenter's Symposium p 19-24 May 1986
Avail: NTIS HC A13/MF A01 CSCL 22A

The Directional Electrostatic Accretion Process (DEAP) is described with respect to both the physical process and its application to manufacturing in space. This high precision portable manufacturing method will revolutionize current practices in manufacturing and repair of spacecraft and space structures. The cost effectiveness of this process will be invaluable to future space manufacturing projects. Author

N86-27353# European Space Agency, Paris (France).
SECOND EUROPEAN SPACE MECHANISMS AND TRIBOLOGY SYMPOSIUM
T. D. GUYENNE, comp. and J. HUNT, comp. Dec. 1985 327 p In ENGLISH and FRENCH Symposium held in Schloss Meersburg, West Germany, 9-11 Oct. 1985; sponsored by ESA, Dornier-Werke GmbH, and DFVLR
(ESA-SP-231; ETN-86-96851) Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Spacecraft mechanisms; motors and actuators; tribology; space stations; and mechanism analysis and testing were discussed. ESA

N86-27356# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
FEATURES OF THE SOLAR ARRAY DRIVE MECHANISM FOR THE SPACE TELESCOPE
R. G. HOSTEMKAMP *In* ESA Second European and Space Mechanisms and Tribology Symposium p 13-17 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Spacecraft mechanisms; motors and actuators; tribology; space stations; and mechanism analysis and testing were discussed.

The Solar Array Drive Mechanism for the Space Telescope is described. Power and signal transfer is achieved by a flexible wire harness for which the chosen solution, consisting of 168 standard wires, is described. The torque performance data of the harness over its temperature range is presented. The off load system which protects the bearings from the launch loads is released by a trigger made from Nitinol, a memory alloy. The benefits of memory alloy and the caveats for the design are discussed. The design of the off load is outlined and test experience reported. ESA

N86-27357# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
HISTORICAL DEVELOPMENT OF SOLAR ARRAY DRIVE MECHANISMS BY BRITISH AEROSPACE
I. D. HENDERSON *In* ESA Second European Space Mechanisms and Tribology Symposium p 19-24 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Solar array drive mechanisms are described. Design and technical features of the Bearing and Power Transfer Assembly and the solar array drive mechanisms for Olympus and Eurostar satellites are outlined. Arrays for large space platforms are considered. ESA

N86-27382# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
DEVELOPMENT AND TESTING OF A DUAL-WOUND DC MOTOR GEARHEAD
B. W. HENSON and J. C. ANDERSON (European Space Tribology Lab., Risley (England).) *In* ESA Second European Space Mechanisms and Tribology Symposium p 193-200 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The development and testing of a dual-wound dc motor and integral gearhead are described. Extensive testing proves its ability to operate in vacuum over the temperature range -45 to +85C with a life greater than 250 hours. The unit has a rated torque output of 1.5 Nm with a nominal output speed of 30 rpm and could be used as a prime mover in many medium speed space applications. Its high overall efficiency means that it can be backdriven. ESA

N86-27385# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
INTEGRATED SENSOR AND ACTUATOR SYSTEM FOR FLEXIBLE SPACE STRUCTURE EXPERIMENTS
T. LANGE and H. HOLZACH *In* ESA Second European Space Mechanisms and Tribology Symposium p 217-220 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

A high accuracy sensor and actuator system for laboratory experiments on flexible structure control, comprising an optical sensor and a magnetic actuator, is presented. It features high linearity and large bandwidth. A special wiring profile was realized for the actuator coil to generate a constant magnetic driving field in a defined working space. This design prevents force variations as a result of relative displacement. The performance is confirmed by tests and experiments. ESA

N86-27391# European Space Tribology Lab., Risley (England).
THERMAL VACUUM INCLINOMETRY: A TEST FACILITY FOR ANTENNA POINTING MECHANISMS
E. W. ROBERTS *In* ESA Second European Space Mechanisms and Tribology Symposium p 261-265 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The development of a measurement and test facility for space antenna pointing mechanisms is described. The system allows measurements of high accuracy and resolution to be made on mechanisms operating under ambient or thermal vacuum conditions (-40 C to +80 C). The basis of the facility is a high precision tilt sensor which can be used in high vacuum. Data acquisition from such sensors is by means of an LSI/11-23 based computer which also allows data processing and programmed control over mechanism movements. In static measurements the system displays high accuracy (+ or - 0.001 deg) high resolution (0.0004 deg) and good repeatability (0.0005 deg). Examples of tests made possible by this measuring system are presented. ESA

N86-27394# Centre National d'Etudes Spatiales, Toulouse (France).
MECHANISMS DEVELOPED IN THE FRENCH SPACE INDUSTRY
R. SALOME and L. PETITJEAN *In* ESA Second European Space Mechanisms and Tribology Symposium p 283-288 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Mechanisms developed for satellite projects such as SPOT, Giotto, TV.SAT, and TELEX-X are described. Solar Array Drives, antenna pointing mechanisms, and hinges for robot arms are presented. ESA

N86-27397# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SPACE MECHANISMS DEVELOPMENT IN THE ESA TECHNOLOGICAL RESEARCH PROGRAM
D. WYN-ROBERTS *In* ESA Second European Space Mechanisms and Tribology Symposium p 305-310 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Spacecraft components, control actuators, space operation mechanisms, instrument mechanisms, deployment mechanisms, and solar array mechanisms are described. Motors, wheels (including energy storage), docking and robotics mechanisms, and masts are discussed. ESA

N86-27525# Rome Air Development Center, Griffiss AFB, N.Y.
PROCEEDINGS OF THE 1985 ANTENNA APPLICATIONS SYMPOSIUM, VOLUME 2
Dec. 1985 372 p Conference held in Monticello, Ill., 18-20 Sept. 1985
(AD-A165535; RADC-TR-85-242-VOL-2) Avail: NTIS HC A16/MF A01 CSCL 09E

The Proceedings of the 1985 Antenna Applications Symposium is a collection of state-of-the-art papers relating to phased array antennas, multibeam antennas, satellite antennas, microstrip antennas, reflector antennas, HF, VHF, UHF, and various other antennas. GRA

N86-27644*# National Aeronautics and Space Administration, Washington, D.C.
APPLICATIONS OF TETHERS IN SPACE: WORKSHOP PROCEEDINGS, VOLUME 2
W. A. BARACAT, comp. (General Research Corp., McLean, Va.) Jun. 1986 502 p Workshop held in Venice, Italy, 15-17 Oct. 1985; sponsored by NASA, the Italian National Space Plan and CNR
(Contract NASW-3921)
(NASA-CP-2422-VOL-2; NAS 1.55:2422-VOL-2) Avail: NTIS HC A23/MF A01 CSCL 13I

Topics addressed include: tethered orbital transfer vehicle operations, Centaur and Shuttle tether technology; tethered constellations, gravitational effects; Shuttle continuous open wind tunnel; optimal control laws, electrodynamic tether technology; and space station facilities.

N86-27645*# Naples Univ. (Italy).
TETHERED CONSTELLATIONS, THEIR UTILIZATION AS MICROGRAVITY PLATFORMS AND RELEVANT FEATURES
L. G. NAPOLITANO and F. BEVILACQUA (Aeritalia S.p.A., Torino (Italy).) *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 2 p 65-77 Jun. 1986 Previously announced in IAA as A85-13279
Avail: NTIS HC A23/MF A01 CSCL 13I

The gravitational, thermal, and dynamic docking effects on tethered platforms were studied. The near-earth environment has gravitational effects such a g-jitters and intermittencies, g-noise, and frequency and amplitude features which may influence life science, materials processing, and fluid processes research and commercial activities. Artificial gravity is produced by minute accelerations imparted by tethers. The magnitudes of gravitational forces produced by tethers 100 and 100,000 m long at various altitudes from 463 to 35,786 km are calculated. Thermal analyses were performed for stainless steel and Kevlar tethers, showing the steel tether could vary 300 m in length and the polyamide 25 m during one orbit. Finally, consideration given to docking with a tethered platform revealed that the center of mass could change, which would produce, however, negligible changes in orbit and therefore gravity. M.S.K. (IAA)

N86-27649*# Naples Univ. (Italy). Istituto Aerodinamica U. Nobile.
TETHERED ELEVATOR: A UNIQUE OPPORTUNITY FOR SPACE PROCESSING
R. MONTI *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 137-147 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

The latest fluid dynamic and material science experiments in the microgravity environment have emphasized the importance of the residual gravity level and of the g-jitter on fluid physics phenomena. The tethered elevator presents the possibility of providing variable g-levels (both steady and g-jitter) around a very low steady g-level (that can be realized when the elevator is near the center of mass of the space station-tether complex). When positioning a variable periodic oscillation to the payload a clean g-jitter disturbance can be obtained that would not be otherwise obtainable by other systems. These two possibilities make the elevator a facility to help resolve a number of still open questions that are preventing wider utilization of the space environment in the microgravity area. B.G.

N86-27706* National Aeronautics and Space Administration. Pasadena Office, Calif.
PROTECTIVE TELESCOPING SHIELD FOR SOLAR CONCENTRATOR Patent
M. J. ARGOUD (Jet Propulsion Lab., California Inst. of Tech., Pasadena), W. L. WALKER, and L. V. BUTLER, inventors (to NASA) 6 May 1986 7 p Filed 22 Feb. 1984 Supersedes N84-25164 (22 - 15, p 2361) Sponsored by NASA. Pasadena Office
(NASA-CASE-NPO-16236-1; US-PATENT-4,586,487; US-PATENT-APPL-SN-582495; US-PATENT-CLASS-126-418; US-PATENT-CLASS-126-419; US-PATENT-CLASS-126-438)
Avail: US Patent and Trademark Office CSCL 10A

An apparatus is described for use with a solar concentrator such as a parabolic dish which concentrates sunlight onto a small opening of a solar receiver, for protecting the receiver in the event of a system failure that could cause concentrated sunlight to damage the receiver. The protective apparatus includes a structure which can be moved to a stowed position where it does not block sunlight, to a deployed position. In this position, the structure forms a tube which substantially completely surrounds an axis connecting the receiver opening to the center of the concentrator at locations between the receiver and the concentrator.
Official Gazette of the U.S. Patent and Trademark Office

N86-28105* National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION SYSTEMS: A BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 2)
Jul. 1986 232 p
(NASA-SP-7056(02); NAS 1.21:7056(02)) Avail: NTIS HC A10 CSCL 22A

This bibliography lists 904 reports, articles and other documents introduced into the NASA scientific and technical information system between July 1, 1985 and December 31, 1985. Its purpose is to provide helpful information to the researcher, manager, and designer in technology development and mission design according to system, interactive analysis and design, structural and thermal analysis and design, structural concepts and control systems, electronics, advanced materials, assembly concepts, propulsion, and solar power satellite systems. The coverage includes documents that define major systems and subsystems, servicing

and support requirements, procedures and operations, and missions for the current and future space station. Author

N86-28407*# National Aeronautics and Space Administration, Washington, D.C.
APPLICATIONS OF TETHERS IN SPACE: WORKSHOP PROCEEDINGS, VOLUME 1
W. A. BARACAT, comp. (General Research Corp., McLean, Va.) Jun. 1986 585 p Workshop held in Venice, Italy, 15-17 Oct. 1985; sponsored by NASA, the Italian National Space Plan and CNR
(Contract NASW-3921)
(NASA-CP-2422-VOL-1; NAS 1.55:2422-VOL-1) Avail: NTIS HC A25/MF A01 CSCL 13I

The complete documentation of the workshop including all addresses, panel reports, charts, and summaries are presented. This volume presents all the reports on the fundamentals of applications of tethers in space. These applications include electrodynamic interactions, transportation, gravity utilization, constellations, technology and test, and science applications.

N86-28410*# Energy Science Labs., Inc., San Diego, Calif.
TETHER FUNDAMENTALS
J. A. CARROLL *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 81-101 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

Some fundamental aspects of tethers are presented and briefly discussed. The effects of gravity gradients, dumbbell libration in circular orbits, tether control strategies and impact hazards for tethers are among those fundamentals. Also considered are aerodynamic drag, constraints in momentum transfer applications and constraints with permanently deployed tethers. The theoretical feasibility of these concepts are reviewed. E.R.

N86-29888*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
PROCEEDINGS OF THE 2ND ANNUAL CONFERENCE ON NASA/UNIVERSITY ADVANCED SPACE DESIGN PROGRAM
Jun. 1986 31 p Conference held at Cocoa Beach, Fla., 18-20 Jun. 1986
(Contract NGT21-002-080)
(NASA-TM-89399; NAS 1.15:89399) Avail: NTIS HC A03/MF A01 CSCL 22B

Topics discussed include: lunar transportation system, Mars rover, lunar fiberglass production, geosynchronous space stations, regenerative system for growing plants, lunar mining devices, lunar oxygen transporation system, mobile remote manipulator system, Mars exploration, launch/landing facility for a lunar base, and multi-megawatt nuclear power system. B.G.

N86-30135*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
A 3-COMPONENT LASER-DOPPLER VELOCIMETER DATA ACQUISITION AND REDUCTION SYSTEM
L. C. RODMAN, J. H. BELL, and R. D. MEHTA Aug. 1985 86 p
(Contract NCC2-294)
(NASA-CR-176929; NAS 1.26:176929; JIAA-TR-63) Avail: NTIS HC A05/MF A01 CSCL 20E

A laser doppler velocimeter capable of measuring all three components of velocity simultaneously in low-speed flows is described. All the mean velocities, Reynolds stresses, and higher-order products can be evaluated. The approach followed is to split one of the two colors used in a 2-D system, thus creating a third set of beams which is then focused in the flow from an off-axis direction. The third velocity component is computed from the known geometry of the system. The laser optical hardware and the data acquisition electronics are described in detail. In addition, full operating procedures and listings of the software (written in BASIC and ASSEMBLY languages) are also included. Some typical measurements obtained with this system in a vortex/mixing layer interaction are presented and compared directly to those obtained with a cross-wire system. M.G.

N86-30584*# Lunar and Planetary Inst., Houston, Tex.
TRAJECTORY DETERMINATIONS AND COLLECTION OF MICROMETEOROIDS ON THE SPACE STATION. REPORT OF THE WORKSHOP ON MICROMETEORITE CAPTURE EXPERIMENTS
F. HOERZ, ed. 1986 105 p refs Workshop held in Houston, Tex., 16-18 Dec. 1985
(Contract NASW-4066)
(NASA-CR-177303; NAS 1.26:177303; LPI-TR-86-05) Avail: NTIS HC A06/MF A01 CSCL 03B

Summaries of papers presented at the Workshop on Micrometeorite Capture Experiments are compiled. The goals of the workshop were to define the scientific objectives and the resulting performance requirements of a potential Space Station facility and to identify the major elements of a coherent development program that would generate the desired capabilities within the next decade. Specific topics include cosmic dust and space debris collection techniques, particle trajectory and source determination, and specimen analysis methods.

N86-30606*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CAPACITOR-TYPE MICROMETEOROID DETECTORS
J. J. WORTMAN (North Carolina State Univ., Raleigh.), D. P. GRIFFIS (North Carolina Univ., Chapel Hill.), S. R. BRYAN, and W. KINARD *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 94-96 1986 refs
Avail: NTIS HC A06/MF A01 CSCL 03B

The metal oxide semiconductor (MOS) capacitor micrometeroid detector consists of a thin dielectric capacitor fabricated on a silicon wafer. In operation, the device is charged to a voltage level sufficiently near breakdown that micrometeoroid impacts will cause dielectric deformation or heating and subsequent arc-over at the point of impact. Each detector is capable of recording multiple impacts because of the self-healing characteristics of the device. Support instrumentation requirements consist of a voltage source and pulse counters that monitor the pulse of recharging current following every impact. An investigation has been conducted in which 0.5 to 5 micron diameter carbonized iron spheres traveling at velocities of 4 to 10 Km/sec were impacted on to detectors with either a dielectric thickness of 0.4 or 1.0 micron. This study demonstrated that an ion microprobe tuned to sufficiently high resolution can detect Fe remaining on the detector after the impact. Furthermore, it is also possible to resolve Fe ion images free of mass interferences from Si, for example, giving its spatial distribution after impact. Specifically this technique has shown that significant amounts of impacting particles remain in the crater and near it which can be analyzed for isotopic content. Further testing and calibration could lead to quantitive analysis. This study has shown that the capacitor type micrometeroid detector is capable of not only time and flux measurements but can also be used for isotopic analysis. M.G.

N86-30627# Deutsche Gesellschaft fuer Luft- und Raumfahrt, Bonn (West Germany).
THE SECOND INTERNATIONAL SYMPOSIUM ON AEROELASTICITY AND STRUCTURAL DYNAMICS
1985 713 p Symposium held in Aachen, West Germany, 1-3 Apr. 1985; sponsored in cooperation with DFVLR, NLR and ONERA
(DGLR-85-02; ISBN-3-922010-28-8; ETN-86-97411) Avail: NTIS HC A99/MF E03

Unsteady aerodynamics and aeroelastic characteristics; active control technology; structural modeling and optimization; structural system identification; and structural dynamics design verification of space structures were discussed.

ESA

N86-30758# European Space Agency, Paris (France).
PROCEEDINGS OF A WORKSHOP ON COMPOSITES DESIGN FOR SPACE APPLICATIONS
W. R. BURKE, comp. Feb. 1986 375 p Workshop held in Noordwijk, Netherlands, 15-18 Oct. 1985
(ESA-SP-243; ISSN-0379-6566; ETN-86-97217) Avail: NTIS HC A16/MF A01

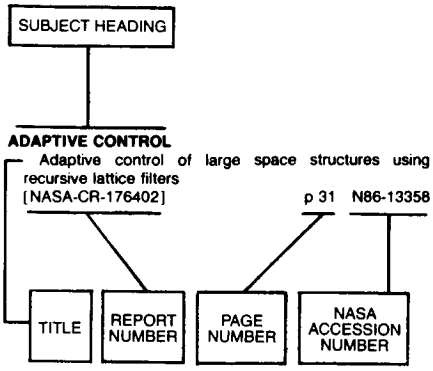
The choice and characteristics of composite materials for space applications, calculation and design methods, and dimensional stability were some areas of discussion in this workshop. Also discussed was integrity control, Ariane applications of composites, load carrying structures in satellites, and satellite antenna and solar array applications.

ESA

N86-31409*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
NASA/AMERICAN SOCIETY FOR ENGINEERING EDUCATION (ASEE) SUMMER FACULTY FELLOWSHIP PROGRAM, 1985
R. G. CHILTON, ed. (Texas A&M Univ., College Station.) and C. E. WILLIAMS, ed. Jul. 1986 733 p Program held in Houston, Tex., 1985
(Contract NGT-44-001-800)
(NASA-CR-171931; NAS 1.26:171931) Avail: NTIS HC A99/MF E03 CSCL 05I

The 1985 NASA/ASEE Summer Faculty Fellowship Research Program was conducted by Texas A&M University and the Johnson Space Center. The ten week program was operated under the auspices of the American Society for Engineering Education (ASEE). The faculty fellows spent the time at JSC engaged in research projects commensurate with their interests and background and worked in collaboration with NASA/JSC colleagues. This document is a compilation of the final reports of their research during the summer of 1985.

Typical Subject Index Listing



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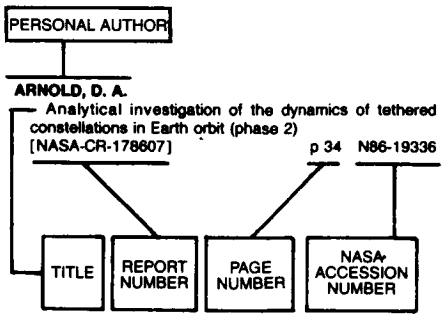
Typical Personal Author Index Listing



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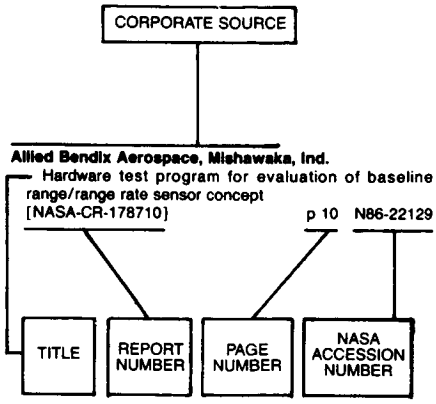

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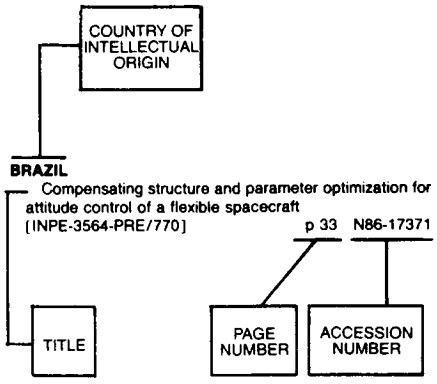

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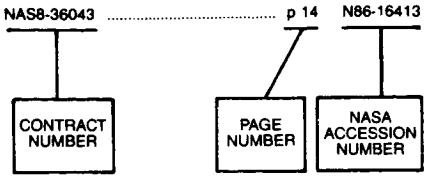

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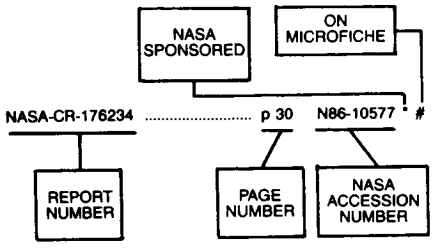

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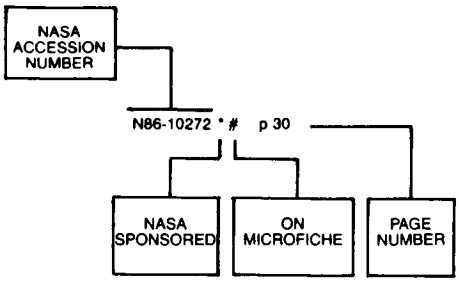

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